VOLUME 9 NUMBER 1

JANUARY 1979

noaa

VOLUME 9 NUMBER 1 JANUARY 1979

noaa

See story on page 30

3 A Message from the Deputy Administrator—by *James P. Walsh*

4 Cleaning Up the Oceans—by *Judith Roales*

10 The Forgotten Z in CZM—by *Ann B. Cowey*

14 The Global Weather Experiment

20 The Troubled Turtle—by *Gerald D. Hill, Jr.*

24 The Small World of Joyce Hawkes

30 "I Love You Jay and I Hope They Clean the Water"—by *Bruce Kantrowitz*

34 The View from Space

36 Oil and the Strait of Juan De Fuca—by *Joan Vandiver Frisch*

40 Diving for NOAA

43 EPOCS in the Equatorial Pacific

46 Toward a Brighter Future

50 When a Star Explodes—by *Louise Purrett-Carroll*

54 **NOAA Profile:** The Plank Owner—by *John Stringer*

58 **Sea Fare:** Palate-Pleasing Prize Winners

60 NOAA/Update

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

National Oceanic and Atmospheric Administration

Richard A. Frank, Administrator

James P. Walsh,
Deputy Administrator

Dr. George S. Benton,
Associate Administrator

Stanley B. Eames
Director, Public Affairs

Roland D. Paine
Associate Editor

Charles G. Thomas
Assistant Editor

Anna V. Felter
Art Director

NOAA is published quarterly by the Office of Public Affairs, National Oceanic and Atmospheric Administration Rockville, Md. 20852, to acquaint readers with the policies and programs of the agency. The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through October 1, 1980.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription $7.50, $1.90 additional for foreign mailing. Single copy $1.40.

A Message From The Deputy Administrator

NOAA probably has many programs that are more dramatic and easily understood than implementation of the new National Ocean Pollution Research and Development and Monitoring Planning Act of 1978. Our responsibilities to protect endangered species such as whales and loggerhead turtles are easily conveyed to the general public. Our efforts under the Fisheries Conservation and Management Act to conserve our marine fisheries are well known. Our Coastal Zone Management program is known as an important NOAA undertaking.

Yet, in real potential to effect changes, P.L. 95-273 is one of the most important pieces of legislation that NOAA has been assigned to administer.

Under the law, the Federal government is required to step back and look at the pollution questions surrounding its many uses of the ocean. These are questions about the level and types of use which the ocean can withstand, the impacts of various uses, what can be done to reduce unfavorable impacts, and what impacts must not be allowed to occur.

It is a forward-looking law that gives us the opportunity to raise scientific questions about the wisdom of our ocean uses and to refine our knowledge and produce answers in time to avert a major disaster that may be waiting in the not-too-distant future.

The law is especially important to NOAA which is charged with protecting living marine resources and their habitat. To reach an optimum yield or optimum sustainable population, both the resources and their habitats must be protected from the detrimental effects of chronic and accidental pollution.

Almost every component of NOAA will be involved in some way with the implementation of P.L. 95–273. A comprehensive program of NOAA research and development and monitoring is being constructed. In addition, NOAA is leading an interagency committee in efforts to develop a comprehensive national plan for addressing the major pollution questions during the next five years.

The work will require that NOAA improve its working relations with other agencies to bring about interagency cooperation and coordination of plans and programs.

It is both an opportunity and a challenge. If our efforts are successful in managing more effectively our ocean uses and reducing pollution dangers, we will have made a major contribution to the well being of the nation.

James P. Walsh
Deputy Administrator
Chairman
Interagency Committee on Ocean Pollution
Research and Development and Monitoring

Cleaning Up the Oceans

By JUDITH ROALES*

AT APPROXIMATELY 11:30 p.m. on March 16, 1978, the supertanker Amoco Cadiz went aground on a rock outcropping off the northwest coast of France, beginning a disaster that eventually emptied 220,000 tons of crude and fuel oil into the ocean. The incident, the worst oil spill in maritime history, was clearly recognized by all as a serious ocean pollution problem.

Several times weekly, barges leave New York, the Delaware Bay, and other Eastern harbors bound for designated dump zones in the Atlantic Ocean. Annually the dumps add about 7 million tons of domestic sewage and industrial wastes, which may contain heavy metals, viruses, and toxic substances, to the ocean waters. The practice is controversial: the Nation is slowly recognizing that this too is a serious ocean pollution problem.

Almost continuously in the United States, agricultural fields are sprayed with pesticides; cooling waters of electric power plants are treated with chlorine to reduce the growth of slime; silted channels are dredged free to allow for safe navigation; and beachside picnickers join ships at sea in tossing their litter—a collection of plastics, metals, glass, and wood—into the ocean waters. There's only a vague feeling, if any recognition at all among the general public, that these activities too may be ocean pollution problems.

"Tragically," Dr. Edward D. Goldberg, Scripps Institution of Oceanography, writes in his overview to a forthcoming study, "so far we have identified the pollutants of concern through catastrophic events." He cites the Minimata Bay poisoning epidemic in Japan which identified mercury methyl compounds, the James River incident in Virginia which identified kepone, and the decreases in reproduction of South Texas sea trout which pinpointed DDT.

"The vast majority of research and development being done in the marine environment is done only in response to environmental outrages and various crises," agreed U.S. Representative George Brown of California in the Congressional Record of debate on S. 1617.

"(We) believe that a major failing in marine environmental research and development is the nearly total lack of any efforts to determine long-term fates and effects of various pollutants in the marine environment," wrote the House Committee on Science and Technology in reporting on the same bill. "It is essential that we move, and move quickly, to discover the scope of the damage already done and, where necessary, take steps to reverse the tide of man's thoughtless destruction of the world's oldest and newest unexplored frontier."

U.S. Senator Warren G. Magnuson summed it up thus: "We need to have an effective, efficient, and well-run research program on ocean pollution. Man-induced changes in the oceans, as in the atmosphere, may well affect the future condition of life on this planet. If we are not prepared to expend the small amount of funds this research requires we truly have our head in the sand."

But the problem is not only the lack of data which allows scientists and decisionmakers to identify pollutants and assess the possible harmful effects. The problem is also bureaucracy: lack of funding, lack of high level interest, lack of a coordinating mechanism for the 8 Federal departments, 9 independent agencies, and 37 subagencies with programs relating to ocean pollution.

This year Congress made a frontal attack on those problems and in April agreed on a final version of the National Ocean Pollution Research and Development and Monitoring Planning Act of 1978. On May 8, President Jimmy Carter signed the bill into law, making the National Oceanic and Atmospheric Administration lead agency in orchestrating the nation's attack on ocean pollution.

The new law, P.L. 95-273, in the words of U.S. Representative John Breaux of Louisiana, has three essential objectives:

"First, to centralize authority to gather necessary information to access and offer recommendations relating to the improvement of the Federal ocean pollution research and development and monitoring effort;

"Second, to insure that the Federal ocean pollution research and development and monitoring effort is coordinated, that the result of federally sponsored ocean pollution research is fully utilized, and that duplication of effort among Federal programs is minimized; and

"Third, to provide guidance to the Federal ocean pollution effort through the evaluation and ordering of national ocean pollution research priorities and needs. Such guidance will insure that essential research needs will not be overlooked and that the greatest possible return will come from each Federal dollar spent on studying the effects of pollution on the marine environment."

The law aims to accomplish these objectives by requiring a comprehensive 5-year plan for the overall Federal effort in ocean pollution research and development and monitoring. The plan will identify the national needs and prob-

Judith Roales is Special Assistant to Deputy Administrator James P. Walsh

lems in specific areas of ocean pollution and establish a priority ranking for resolving those problems. It will explain the Federal capability—in terms of personnel, facilities, and program goals—for dealing with ocean pollution problems. And it will recommend changes in existing programs and budgets to assure that priority problems are attacked and duplication of effort is minimized.

The plan will be continually updated, every two years, to reflect changes in pollution problems and priorities or the successes and failures of research projects.

NOAA's responsibilities under the law are formidable. As lead agency in the preparation of the plan of action, NOAA is charged with assuring that the Federal program of research and development and monitoring will provide adequate information on the impacts of ocean use so that conflicts can be resolved, protective measures taken, and regulations formulated to make the most efficient use of the oceans.

P.L. 95–273 authorizes NOAA to award grants or contracts for new projects that may be required to fill the gaps in areas of high priority. In FY '79, $5 million are authorized for this purpose. The law also requires that NOAA make sure that the results of all ocean pollution research and development and monitoring programs conducted or sponsored by the Federal Government are made available in a timely and useful form to all decisionmakers and others having an interest in ocean pollution.

Work has begun on several fronts: the President's Office of Science and Technology Policy has established an Interagency Committee on Ocean Pollution Research and Development and Monitoring to assure that the national plan will reflect the needs and programmatic mandates of the entire Federal Government; a workshop has been held to define pollution problems and research needs in scientific terms; an inventory is being conducted to identify all Federal programs of research, development or monitoring relating to ocean pollution; a workshop is planned to involve Federal, State, and local decisionmakers and users of ocean pollution data in identifying and giving a priority ranking to the nation's ocean pollution problems; and the NOAA programs in Ocean pollution are being scrutinized to determine how they will relate to the national plan.

The Interagency Committee

The Interagency Committee, chaired by NOAA Deputy Administrator James P. Walsh brings together 12 Federal agencies to work on the national plan, which must be submitted to the Congress by February 15, 1979. Dr. Stephen A. Gage, Assistant Administrator for Research and Development, U.S. Environmental Protection Agency, is vice chairman.

Other members of the committee are:

Dr. H. William Menard, Director, U.S. Geological Survey, Department of the Interior,

Dr. Ruth M. Davis, Deputy Secretary for Research and Engineering, Department of Defense,

Rear Admiral A.P. Manning, Jr., Chief of the Office of Research and Development, U.S. Coast Guard, Department of Transportation

Dr. Ferris Webster, Assistant Administrator for Research and Development, NOAA, Department of Commerce,

Dr. Helen M. McCammon, Senior Oceanographer, Division of Biomedical and Environmental Research, Department of Energy,

Edward Strohbehn, Executive Director, Council on Environmental Quality,

Dr. John Slaughter, Assistant Director for Astronomical, Atmospheric, Earth and Ocean Sciences, National Science Foundation.

Dr. Howard L. Sanders, Woods Hole Oceanographic Institution, collects intertidal samples in an area where fuel oil had been spilled several years before.

Dr. William P. Raney, Chief Engineer, Office of Space and Terrestrial Applications, National Aeronautics and Space Administration,

Dr. Julius B. Richmond, Assistant Secretary for Health, Department of Health, Education and Welfare,

Glen Loomis, Coordinator for Land, Air, Water and Solid Waste, Department of Agriculture, and

John Dyer, Office of Management and Budget.

Lowell Martin, of the NOAA Office of Policy and Plans, is executive secretary of the Interagency Committee. Martin is a maritime policy analyst on full-time detail to the project from the Coast Guard Office of Merchant Marine Safety.

The Interagency Committee is the focal point for interaction between all of the agencies with responsibilities or interests related to ocean pollution. The group provides guidance to working level subcommittees which have been established to produce major ingredients of the national plan. It also provides the contact point for reaching into the various agencies for information or assistance. Since the objectives of P.L. 95-273 cannot be accomplished without sincere interagency cooperation and coordination of programs, individual committee members will be a key resource when the Interagency Committee has produced and approved a national plan that may call for modification of some existing programs.

To date, the Interagency Committee has split into four subcommittees, each addressing a major component of the legislation. EPA heads a group charged with identifying the national needs and recommending a ranking of those needs to the full committee. NSF and NOAA, respectively, head groups which will suggest an R&D program to address national needs and a monitoring program to track the pollution situation. The R & D and monitoring groups also will compare existing programs and facilities with the programs they have developed and recommend modifications. The fourth group, headed by Interior, will develop a data management scheme by which information generated for the national plan and the results of research, development, and monitoring activities can be made available to users.

Plankton nets collect samples for scientists who seek to understand the ocean system.

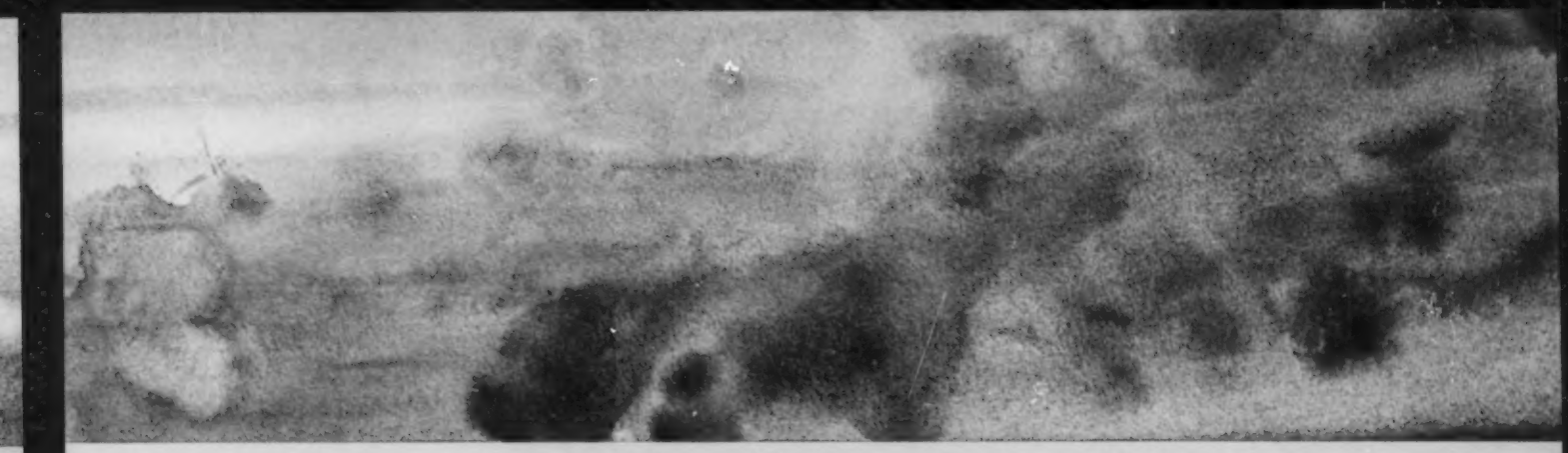
Dr. Richard Harbison examines zooplankton aboard R/V Atlantis.

The Workshops

A scientific workshop was convened for NOAA in July 1978 by Dr. Edward D. Goldberg, a long-time and highly respected expert in the field of ocean pollution. Dr. Goldberg's intent was to define the problems of pollutants, "the antagonists of the oceans," as some of the nation's leading scientists see them. He asked the 70 scientists gathered at Estes Park, Col., to provide tactics for early recognition of potential pollutants in the coastal zone and to outline a program of research and monitoring that is relevant to the recognized and potentially solvable problems in marine pollution.

The scientists focused on the problem of ascertaining biological impacts, the need for surveillance programs to monitor pollutants, and the characteristics of nine specific categories of pollutants: synthetic organic chemicals, chlorination products, dredging and other large volume waste disposal, litter, artificial radionuclides, microorganisms, heavy metals, biostimulants, and fossil fuel compounds. Later Goldberg noted that the workshop had failed to cover runoff which should also be addressed as a unique and potentially dangerous source of pollution. There may be other categories which also should be addressed, but the Estes Park workshop made a start, a first cut, at defining the scientific problems—the lack of basic knowledge about fates, effects, transport, interaction, reaction, uptake, assimilation, degradation, retention, speciation, accumulation, the factors which govern change, and the means for measuring impacts of all kinds—which haunt most scientists who attempt to provide usable information about marine pollution problems.

Input from the scientific workshop was balanced with the views and reasoning of participants in a second workshop held in the Washington area in November. At that gathering, State and Federal regulators, judicial and legal experts, and representatives of various industry and environmental or other special interest



The rosette water sampler, an important tool for collecting several samples at once. Environmental data continuously transmitted to the ship from the instrument helps scientists determine best depths for closing sample bottles.

Researcher Roy Smith works with water filters in a glove box to avoid sample contamination aboard R/V Knorr.

groups helped the Interagency Committee determine what information about ocean pollution and its impacts is needed to make reasonable decisions about ocean uses.

The reports of the two workshops will be a major source of information and insight upon which the Interagency Committee will draw when it begins the arduous, and unavoidably controversial, task of folding together science, law, economics, aesthetics, and politics to produce a plan that will serve the nation well.

The Federal Inventory

Another cache of information will be the Federal inventory. The inventory is the NOAA equivalent of a "1978 census," a headcount of every laboratory, every ship and dock, every aircraft, every satellite, every aquarium, every testing tank and model basin, every library and computer system in the Federal Government's arsenal of research tools dedicated to marine pollution. It will also include an itemized listing of every single research project related to ocean pollution and funded with Federal dollars.

The inventories include complete descriptions of the equipment or projects, especially personnel requirements and funding details.

The logistics of making such an inventory are obviously complex. The problems of standardizing and computerizing the information are doubly so. But the purpose of the activity is simple: the law requires, and the committee needs to know, who has what and how can it be used to the best advantage for the entire nation? What facilities can be used more intensely or jointly used? And eventually, how do the projects underway match up with the priorities which will be set?

In NOAA, with the inventory close to complete, about 30 facilities and more than 400 research programs representing an estimated $45 million have been reported. However, those figures are very preliminary and are probably inflated because of duplicate reporting by both the funding and the working organization and because of the inclusion of some projects, such as current surveys, which may be only tangentially related to pollution.

With about half of the Federal agencies being surveyed accounted for, 125 research projects have been reported outside of NOAA. The project reports had not yet been reviewed to eliminate duplication or inappropriate inclusions, and two of the largest sponsors of pollution-related research, the Department of the Interior and the Environmental Protection Agency, had not yet completed their inventories when this article was written.

The NOAA Program

As the Interagency Committee proceeds toward a national plan which encompasses all Federal activities, a task force of NOAA personnel has been brought together in Rockville to develop a comprehensive ocean pollution program within NOAA. The program is mandated by Section 5 of P.L. 95–273 and includes projects formerly required by title II of the Marine Protection, Research and Sanctuaries Act of 1972 as well as any new projects required by the national plan which are appropriate to NOAA.

The task force will provide an internal blueprint for responding to NOAA's programmatic responsibilities under the law. When it has finished its assessment of existing NOAA projects, it will have compiled a more comprehensive picture of NOAA's environmental program than has ever existed before, according to Dr. Joseph Angelovic who leads the group.

With the existing program well defined, the task force will work with early data from the Interagency Committee to begin modifying the NOAA program to respond to the national needs and priorities.

Obviously, there is much work ahead for both the Interagency Committee and the NOAA task force. Everyone working knows that the revised NOAA program and the plan submitted in response to the February 15, 1979 deadline are just the beginning. Following the submission will come efforts to implement the plan and an unending series of revisions to keep it current, responsive to national needs, and—it is hoped—reflective of diminishing pollution as the ocean and its antagonists come into closer harmony. □

Urban Waterfronts:

The Forgotten Z in CZM

By ANN B. COWEY*

MOST PEOPLE RESPONDING to terms like "shorefront" and "coastal" think immediately of the chance to enjoy a sea bath, soak up the sun, gather shells, build a sand castle, cast a line, launch a boat, or glimpse wave-splashed rocks and glimmering waters. These perceptions, accurate as they may be, disregard waterfront images closer to home and mock the fact that the majority of our Nation's population lives in cities or metropolitan areas bordering the coast. Nine of America's 10 largest standard metropolitan statistical areas are coastal.

Historically, the coastal cities—the important seaports of their day and the centers of power and commerce—were the key links of trade and transport. Time and changing technologies, however, have altered this pattern and left a good bit of derelict land and deteriorated waterfront in their wake. The urban waterfront, once a hub of activity, has been walled off (both literally and psychologically) from the inhabitants of most American cities.

With few exceptions, such as Chicago and San Francisco, the image of the American coastal city and the water's edge is hardly notable, in dramatic contrast to the much painted, photographed, and praised foreign counterparts to which thousands of people flock, crossing oceans to do so. Millions of people flee the cities and suburbs in this country in a mad dash, or more likely a maddening crawl, to a shoreline miles from home to enjoy the water and its pleasures. Other millions remain behind, lacking either the means or mode to travel to the water.

To overlook the enormous potential of the waterfront at a city's very doorstep that could be used to satisfy many people's desire for water-related recreation, open space, and overall enjoyment would be a missed opportunity of serious consequence. It seems all the more wasteful in terms of both energy and land consumption when recylcing vacant or forgotten areas within a city could reduce

Small shops and apartments in former warehouse section of Boston's waterfront (right). The granite buildings housing them had become such an eyesore in the early 1960's that they were slated for demolition.

* *Ann B. Cowey is a Staff Assistant in the Office of Coastal Zone Management*

transportation costs and alleviate development pressures on remaining non-urban natural acreage.

The creation of urban waterfront problems did not happen overnight, however. From the day in 1620 when the pilgrims landed at Plymouth, and for 200 years or more thereafter, coastal settlements were of prime importance to America. Old maps show that the important cities of the day were harbor-oriented. Etchings and paintings document the busy social and commercial life of these early towns. Their ports were the gateways to the New World. Cargo from around the globe transferred hands on their docks. But the remaining seventeenth, eighteenth, and nineteenth century structures—houses, assembly halls, churches, streets, shops, and warehouses—more often than not stand today only as architectural relics of that bygone era. A few continue to be used; others are venerated as museums; still others hide beneath scars of decay.

Ironically, as the Nation grew, dependence on ports as keystones of the economy diminished. The city waterfront's status changed from parlor to back room as the effects of the industrial revolution, population growth, railroad imperialism, the automotive avalanche, and the dizzying technological changes of the postwar era totally altered our economic and social development.

The city expanded away from the water's edge. The harbor continued to serve the city, but in a lesser capacity. Rather than being the focal point of town life, it became only a piece of the metropolitan and regional whole. An integrated yet heterogeneous way of life was replaced by a more fractionalized one. Most housing and commerce moved away from the wharves, leaving fishing, shipping and water-related industries to occupy the area. Adjacent wetlands were drained and filled as more land was needed. The water lost its ability to absorb the increasing waste deposited there. Their assimilative capacity overtaxed, waterfronts fell victim to pollution, loss of aquatic life, and disintegration. The situation reached a point that led one observer to note: "The common urban waterfront is hardly approachable, much less swimmable, encrusted with wharves, switching yards, sewage outfalls, and other industrial barnacles. It is the true civic outcast, the ghetto of ghettos, familiar only to longshoremen, sanitary engineers, and carp."

In the waterfront area of many American cities, a rough and tumble enclave remains where once a total community thrived.

Certain technological changes in the past 20 years have been responsible for the further decline of the urban waterfront. First, the shift from break-bulk to containerization in the shipping industry caused a geographical shift from the old, downtown ports to newer areas, because container operations require a change of scale: more acreage for backup space, deeper and wider channels for ships, and access to good transportation.

Second, the truck and interstate highway system overwhelmed the railroads as the primary transportation link for cargo. Many industrial concerns moved away from the congested, older waterfronts to take advantage of road networks located elsewhere.

Third, long distance voyagers who, with bon voyage parties in tow, once flocked to ocean liners, now board jets.

Another view of Boston's former commercial warehouse section shows present-day mixture of apartments, shops, marina.

Fourth, bridges spanned bays and rivers, making ferry boats obsolete. The gaping slips, rotting piers, empty warehouses, carless rails, and deteriorating, vacant buildings that pockmark the coastline stand in mute testimony to these changes. "No swimming" warnings, flotillas of rubbish, debris, and murky water present the water pollution story. The waterfront has lost its prominence in the economic as well as the social life of most American cities.

Nevertheless, recently there has been an increasing interest in the waterfront. In 1965, the White House Conference on Natural Beauty devoted an entire panel to "Water and Waterfronts." In part of its discussion, the panel highlighted four recommendations pertaining to urban waterfronts:

- Water and waterfronts need special treatment in all city plans. Historic waterfronts, especially, should be preserved, restored and protected. Waterfront land and access should be gradually limited to those activities which actually require waterfront location or access.

- Urban Waterfront Districts, somewhat along the lines of the historic and highly successful Soil Conservation districts, should be established. Existing watershed protection programs should be modified to include multipurpose protection, not only in the agricultural areas where this now applies, but in urban areas as well.

- New techniques for extending the use of waterfront lands to metropolitan residents should be developed. There is far too little actual water's edge available to the typical city resident. The arts of the architect and landscape architect should be coupled with the engineer's skills to open up the edge to the populace. Fill and rubble should be used creatively as a resource, rather than as a waste material, to complement the urban design plan.

- Urban renewal powers should be used in a comprehensive way to improve waterfronts and set them free from transportation barriers, blight, and dumps in order to realize their environmental values. In spite of the panel's suggestions, "Urban Watershed Districts" have not been forthcoming. Access to the waterfront remains a national problem, and many waterfront plans are buried in the files of city halls.

However, something of a waterfront renaissance has begun. Numerous rehabilitation and renewal projects funded by the Department of Housing and Urban Development channeled money into old waterfront areas. More than 80 cities have been identified as involved in some sort of waterfront project, ranging from code enforcement to full scale, area-wide renewal.

Building on the idea that America's coastal cities indeed have the potential to be cultural, esthetic, and commercial focal points, NOAA's Office of Coastal Zone Management has been taking a hard look at our urban waterfronts, and throwing in some hard cash in the bargain. Over the life of the national CZM program a number of apparently unrelated items began to coalesce:

- The CZM Act called for the development and implementation of geographically comprehensive State CZM programs, yet it seemed to be primarily concerned with the protection of relatively undeveloped coastlines or those under developmental pressure. The complex issues of urban shorefronts were really not addressed back in 1972.

- Many states developing CZM programs initially did not want to deal with urban waterfront issues, or chose to make urban and undeveloped areas subject to the same management techniques.

- The national CZM program is viewed by many as predominantly environmental in nature, a perception borne out by the language and legislative history of the CZM Act. Development interests, however, have legitimate functions in the coastal zone and increasingly are clamoring for more explicit recognition in State CZM programs. Urban waterfronts represent a significant geographic area of the coastline where development not only can be tolerated, but where it may be actively encouraged within an affirmative CZM framework.

- A new requirement was added by the Congress in 1976 for state CZM programs to plan for increasing public access to coastal beaches and other shorefront attractions. In addition, it authorized a $25 million grant program for land acquisition for bringing about such public shorefront access. Taken together, these two amendments constitute a mandate for States to look at the issues regarding the ability of the public to reach and use public

Two "befores" and one "after". Below, an abandoned ferry slip in Brooklyn, N.Y., typical of unused and uninviting urban waterfronts. Long Wharf in Newport, R.I., 75 yards from the harbor, looked rundown and shabby 20 years ago (right), and is now neat, attractive, and inviting (facing page).

shorefronts. Since the intensity of the access issue is generally directly related to the number of people desiring such access, it is clear that a major focus for access planning and management in CZM will be in and around urban areas.

This last point deserves special emphasis. The 1976 Amendments to the Coastal Zone Management Act include a shorefront access plan that requires state management programs to develop "a planning process for the protection of an access to public beaches and other public coastal areas of environmental, recreational, historical, aesthetic, ecological, or cultural value." While the language does not explicitly mention urban waterfronts, all of these characteristics can be found in urban coastal areas, particularly historic, cultural, and aesthetic features. The regulations go on to say that "special attention should be given to recreational needs of urban residents for increased shorefront access" echoing earlier Federal expressions of concern by both the Stratton Commission and the Department of the Interior about the need for recreation access in and near urban areas.

The issue of reclamation and reuse of waterfront area, plus the provision of access to and along the urban coastline, have come to deserve special attention, and OCZM has recognized this fact. By the end of fiscal year 78, roughly 30 local waterfront projects had been funded in 13 states representing a commitment of more than half a million dollars.

OCZM hopes that these small $25-30,000 grants will serve a function similar to those of the National Endowment grants, acting as catalysts or filling gaps where funding is not available. The projects cover a broad range of activity from conceptual planning through pre-engineering studies as well as detailed architectural drawings and engineering specifications. The majority of the projects deal with the issues of waterfront access and recreation through either parks or marinas. They include such projects such as:

- A design and planning study in Norfolk, Va., to construct a public shoreline walkway and park area.
- Design and engineering plans in Gloucester, Mass., for park, access and support facilities, including walkways and a wharf overlook, for observation of the commercial fishing areas as well as a plaza for city festivals.
- A study and cost estimate of the redevelopment of Lincoln Park in New Orleans—an old amusement park and beach—with the goal of providing new waterfront access.

Other projects are aimed at more comprehensive waterfront management. For example, Gulfport, Miss., will determine the economic feasibility and subsequent environmental impacts of development in a portion of its harbor for a wide range of economic, transportation, cultural, aesthetic, and recreational goals. Wilmington, Del., Calais, Me., and St. Mary's, Ga., are all developing similar comprehensive plans.

The redevelopment of an underutilized marine passenger terminal and waterfront area for more people-oriented activities will be studied by the city of Honolulu. Portsmouth, N.H., will conduct marine engineering and planning studies for docking facilities.

In June of this year a memorandum of understanding was signed between OCZM and the Interior Department's Heritage, Conservation and Recreation Service, bringing broad areas of common concern together, including urban waterfronts. Thanks to a CZM urban grant, the city of Detroit, for example, is designing several parks. Detroit is also participating in the Commerce Cities Program—a program within the Department of Commerce designed to bring together various Commerce resources in developing a unified strategy for solving city problems.

A project being funded by OCZM in Buffalo, N.Y., will enable the city to move more quickly on a bike/pedestrian pathway along its waterfront.

What is the future of this facet of coastal zone management melded with community development, of taking a sow's ear and transforming it magically into a silk purse with some money in it? Will it become a fad of the late '70's and early '80's with some successes but many ill-fated efforts? Can it really achieve the contemplated golden objectives?

Certainly, redevelopment on the waterfront is going to be expensive, perhaps more so than in other parts of cities. A heavy financial and moral commitment will have to be made by public leaders. A working partnership between the business community and municipal officials will often have to develop, be nurtured and maintained over time. Public apathy will have to be overcome.

But with all of the actual and potential pitfalls, and recognizing that many urban initiatives that are proclaimed nationally often fail because they are less substance than rhetoric, the Office of Coastal Zone Management believes that the redevelopment of urban waterfronts and all that it can bring stand a good chance for success.

Waterfront redevelopment covers a small, but coherent part of any city's urban fabric. With a limited geography upon which the public and local planning agencies can focus there appears to be a greater likelihood for success in "do-able" projects.

The concept is politically attractive. While execution of waterfront redevelopment may prove to be vexing at times, there appear to be few political liabilities for either office holders or candidates at all levels of government in embracing the principle.

Finally, the tremendous success that the more notable waterfront redevelopment projects have enjoyed will attract new private investment capital to future projects. Investors are constantly looking for new real estate opportunities, and what better opportunity than a location close to existing downtown areas, where the public sector may well bear a good part of the development costs and where large numbers of people are likely to be drawn because of the amenities of the shoreline.

The years ahead will be interesting and exciting in this area. They may well begin to make some modest but significant changes to the face of urban America. □

The Global Weather Experiment

"Some 147 Member nations of the World Meteorological Organization will...be involved in the enterprise, the largest international experiment ever carried out."

December 1, 1978 - November 30, 1979

THE GLOBAL weather experiment, more than 10 years in preparation, is a vast undertaking—truly breathtaking in scope. Some 147 member nations of the World Meteorological Organization will in some way be involved in the enterprise, the largest international experiment ever carried out. Seventy countries and five international organizations will directly contribute.

For periods stretching over an entire year (beginning on December 1), the weather in every part of the world will be monitored by an unprecedented array of observing systems: 9 space satellites, more than 50 research vessels, 110 aircraft (including 10 research planes), 300 high altitude constant-level balloons, and 300 instrumented drifting buoys. These systems will be adding to the mass of data already generated daily by the existing surface-based World Weather Watch which produces observations from 3,400 land stations, about 7,000 merchant ships, some 800 upper air stations, 9 weather ships, and 1,000 or more commercial aircraft.

This torrent of information will be ultimately funneled, via a worldwide communications net, to various data centers around the globe. Some of the data will be relayed in "real time," almost as they are generated. Thus, they will be used in preparing daily weather forecasts. But much of the information will be delayed and will take hundreds of scientists more than a year to fully process and assimilate—even using the most powerful computers in existence, "number crunching" giants that can perform up to 80 million instructions per second.

The result, though, will be the most comprehensive record of the world's weather ever constructed. This immense "data set" will be invaluable in learning more about the causes of weather behavior, constructing more accurate models for forecasting, determining the practical limits of weather prediction, and designing the best global weather observation system the world can reasonably afford.

Why is this great effort necessary? Weather forecasts are indeed significantly better than they were 10 years ago. But in spite of the scientific and engineering advances of the past decade (including satellites and sophisticated computers), forecasts are still lacking in precision. The further out the prediction, the more tenuous the accuracy. Meteorologists still have much to learn about the basic physical processes that underlie weather behavior.

For example, they know that so-called "long waves," formed by the spinning of the earth, play a vital role in weather. But they do not know how the longer vertically stacked atmospheric waves, some 10,000 to 40,000 kilometers long and encircling the globe, operate. Because of inadequate knowledge of long waves and other complex weather dynamics in areas such as the tropics, scientists are unable to construct the kind of accurate mathematical computer models needed for longer range forecasting.

They also lack sufficient data for such forecasts—even though well in excess of 40,000 observations daily are generated by the existing land-based World Weather Watch and orbiting weather satellites. Only about 15 percent of the earth's surface is now regularly monitored. But the countless air masses that make up the atmosphere are constantly in motion, affecting conditions elsewhere. The weather is always changing.

Only the northern hemisphere is systematically observed. The vital equatorial tropics and the vast, lonely expanses of the southern oceans are barely covered. Yet what happens south of the equator profoundly affects the weather of the northern hemisphere.

The longer the forecast, the more of the atmosphere and oceans need to be observed. A 1- to 2-day prediction for Washington, D.C.,

for instance, requires measurements from the earth and sea surfaces up to 10 kilometers into the atmosphere. Such measurements must stretch from 20 degrees north latitude to around 70 degrees north. A 4- to 10-day forecast requires observations from a meter or so below the sea surface to more than 30 kilometers altitude and from 20 degrees south latitude to the north pole. For predictions beyond 10 days, a truly global observing system is necessary, one that includes measurements from several meters below the sea surface.

In the past, there was no feasible way to gather such necessary data from south of the equator. Only about 120 land-based weather stations now take upper air soundings in the southern hemisphere (compared to more than 700 in the northern hemisphere). Building hundreds of new upper air sampling facilities, each of which could cost hundreds of thousands of dollars a year to operate, would be prohibitively expensive. Moreover, the southern hemisphere is overwhelmingly water, with few suitable land masses and islands on which to locate the great number of upper air stations needed. A fleet of weather ships, each of which costs several million dollars a year to run, is also out of the question.

Even if significant amounts of data from the tropics and southern hemisphere were available, computers in the past were not sophisticated enough to produce sufficiently accurate and detailed forecasts. More calculating power was necessary. And computers with such power just were not available.

Advancing technology, however, has made the Global Weather Experiment possible. Improved satellite observing systems can now regularly monitor temperature and wind speed over the empty reaches of the southern hemisphere (at reasonable cost). And powerful new super-computers have been developed which can handle as many as 80 million instructions per second.

With the improved satellites, special observing systems, and the existing World Weather Watch, meteorologists will be able to monitor the planet's atmosphere more comprehensively than ever before. The new giant computers will be able to assimilate the resulting flood of data, enabling scientists to gain a better understanding of the world's weather.

This better understanding of the global atmosphere's behavior—and the physical processes underlying that behavior—will help them to develop more accurate mathematical computer models. Such models are necessary for producing more reliable extended weather predictions.

How far ahead will it be possible to extend such accurate forecasts? This is a central question that will be addressed by the Global Weather Experiment. Currently, weather predictions up to several days are reasonably accurate. With the unprecedented world coverage of the experiment and the unique volume of resulting information, meteorologists may be able to extend more precise forecasts to 6 to 10 days, or possibly 14 days in advance.

After the operational phase of the experiment ends in November 1979, scientists at research institutions in the United States and Europe will be seeking to learn what data is crucial to extended forecasting. What must be measured in the atmosphere? How accurately and how often? They must find what errors are involved in various observing systems such as satellites, balloons, buoys, and so on. They have to know how these errors are correlated among observing systems.

All these facts—what nature tells the scientists must be measured, what the observing systems are able to measure, the errors in the systems—have to be analyzed in order to develop an optimum observing system which the world can afford. The process is evolutionary; one which will take at least several years. The result will determine what must be done in the future to improve weather forecasting.

A final goal involves climate. By learning more about the physical mechanisms controlling weather behavior during the year-long Experiment, meteorologists can accumulate indispensable "baseline data." With such data, they will be able to develop better climatological computer models with which to experiment and improve their understanding of annual fluctuations in weather behavior.

Global Weather Experiment Observing Systems

The basic observing system for the Experiment will be the existing World Weather Watch. This system will be augmented during the Experiment. Temporary upper-air stations will be established on five islands in the western Pacific. Upper air facilities will be upgraded on five western Pacific Trust Territory islands, Ascension Island in the tropical Atlantic, and Diego Garcia in the tropical Indian Ocean.

Satellites will play a central role. For the first time, five geostationary satellites will monitor the atmosphere from fixed points 36,000 kilometers above the equator. The spacecraft, some 60 to 80 degrees longitude apart, will provide information on large scale, atmospheric motions in a broad 100 degree band—50 degrees north and south of the equator.

Three of these are U.S. satellites, stationed at 135 degrees west, 75 degrees west, and 60 degrees east longitude. One has been aloft since February 1975. The other two were launched in June 1977 and June 1978. Japan's first geostationary satellite (called "Himawari") was sent up in July 1977 and is hovering above Japan at 140 degrees east. The European Space Agency's "Meteosat," launched in November 1977, is stationed at 0 degrees longitude.

The five geostationary satellites will provide both visual and infrared images of the atmosphere, visual images at hourly intervals during daylight, and infrared images at half hour intervals during most of the day and night. By measuring cloud motions in successive images, analysts will be able to estimate wind speed and direction at two or three levels in the atmosphere. Both the European and Japanese spacecraft are also instrumented to determine sea surface temperatures.

A new generation of U.S. polar orbiting satellites will be circling the earth at altitudes of around 830 and 870 kilometers. NASA's TIROS-N spacecraft was launched Oct. 13, 1978. The National Oceanic and Atmospheric Administration's NOAA-6 is slated to go into orbit in early 1979. The two satellites will not only supply day and night vertical profiles of the atmosphere's temperature and humidity but also global sea surface temperatures and cloud images.

A U.S. research spacecraft will provide additional information. NASA's Nimbus-G, launched Oct. 24, 1978, is in a near-polar 950 kilometer high orbit around the earth. It monitors sea surface temperatures, ocean surface wind speeds, ocean rainfall, stratospheric temperature profiles, and changes in sea ice concentrations.

The satellites will give scientists a wealth of global meteorological data never before available. But meteorological information from space is all derived from indirect measurements that generally are not as accurate as direct measurements. Moreover, it is not possible to get a complete profile of winds at various levels of the atmosphere from satellite cloud images in the tropical equatorial belt where much of the northern hemisphere's weather originates.

To fill in important data gaps in the equatorial belt and further down in the southern hemisphere, an array of special observation systems will be operating during two 2-month "special observing periods"—Jan. 5–Mar. 5, and May 1–June 30. Some of the systems will not be running throughout the entire four month span. But all will be operating during two 30-day "intensive observation" periods from Jan. 15 to Feb 13 and from May 10 to June 8. Most of the special systems are primarily designed to provide vital tropical wind measurements.

Some 50 ships, mainly oceanographic research vessels, will be making such wind measurements. Balloons, carrying instrument packages called radiosondes, will be released twice daily (at noon and midnight, Greenwich Mean Time). Some vessels are equipped with costly special launching platforms to enable the balloons to be tracked by radar. However, the majority will be using a new and far less expensive system. The radiosondes will receive signals from a global radio navigation system called "Omega Navaid." These signals are transmitted back to the vessels, thus giving precise "fixes" on the balloons. They can then be monitored six times a minute. By tracking the movements of the balloons, technicians on the ships (with either type of equipment) can determine wind speed and wind direction at levels up to 90,000 feet. The balloons also will transmit temperature and humidity readings.

The ships will each be surveying roughly 500 square kilometers. But three-quarters or more of the vessels, which come from approximately 22 nations (including 14 from the USSR, 9 from the US, and 2 from the Peoples Republic of China), are primarily engaged in oceanographic research.

To fill in the rest of the equatorial belt, the U.S. Air Force and NOAA will fly daily wind measuring sorties from three widely separated locations. Two Air Force C-135s will range over the equatorial Atlantic from Ascension Island. Four Air Force C-141s will operate between Hawaii and Acapulco, observing the central and eastern Pacific tropical zones. NOAA aircraft, a C-130 and two P-3s, will fly

Hundreds of instruments . . . instruments carried on satellites, aircraft, balloons, and ships . . . instruments dropped by parachute . . . instruments installed on towers, buildings, and buoys . . . will be used during the Global Weather Experiment for the most complete scientific record ever attained over such a huge area. Above, an impression of the vast network; on facing page, some of the platforms to be used.

out of Diego Garcia in the Indian Ocean, covering areas not being monitored by surface ships.

During the two intensive month-long observation periods, one mission daily will be flown in the Atlantic, three daily in the Pacific, and two daily in the Indian Ocean. The flight paths will vary, depending on the time of year and the location of research ships (especially in the Indian Ocean). The idea is to maintain as complete a surveillance of the equatorial zone as possible—without duplicating efforts.

The aircraft will eject parachuteborne dropwindsondes every 350 kilometers along their flight paths. The instrument packages are identical to those used on the research ships. Omega Navaid signals received by the dropwindsondes will be transmitted back to the planes, allowing the descending instrument packages to be precisely tracked. The result will be a wind profile down to the ocean surface. At the same time, sensors in the package will send temperature, humidity, and pressure readings. The jet aircraft will measure the winds below 42,000 feet, the propeller-driven planes over the Indian Ocean from approximately 30,000 feet.

While the aircraft will provide an impressive range of coverage, they have a limitation. Their wind profiles start just below cruise flight levels. To get higher altitude wind data in a belt 20 degrees north and 30 degrees south of the equator, the National Center for Atmospheric Research, (Boulder, Colo.,) will operate a constant level balloon monitoring system.

During each special observing period, 150 super-pressure mylar balloons will be released from Canton Island in the Pacific and Ascension Island in the Atlantic (approximately 160 degrees apart near the equator). Some 75 balloons will be launched from each site at 6-hour intervals, beginning 6 days before the 30-day intensive observing periods.

The balloons will float at around 46,000 feet. Every 6 hours, they will be tracked by doppler radar from one or both of the polar orbiting satellites (each balloon will transmit identifying signals picked up by the spacecraft receivers). The data will be recorded and relayed to telemetry stations about every 101 minutes. The information from each balloon gives readings on winds and temperatures.

Scientists hope that the balloons will stay aloft at least 30 days and complete three or more circuits around the earth. But the flight paths are dependent on prevailing winds. Thus, the balloons could cluster together or stray north of their tropical belt. Indeed, if a balloon does stray over certain land areas, a magnetometer which measures the earth's magnetic field will automatically cut the instrument package loose.

In the equatorial belt there is considerable ship traffic. In the Pacific, especially the western Pacific, there are a number of island weather stations. But in the vast reaches of the southern hemisphere, there is little land area and ship traffic is sparse. Most of the wind, pressure, humidity, and temperature data from this lonely region will come from two U.S. polar orbiting satellites. However, the spacecraft information is not as precise as meteorologists would wish.

By supplying sea surface temperature and pressure "reference points," the accuracy of derived satellite wind and temperature measurements will be significantly improved. To provide these "anchoring points," some 300 drifting buoys have been contributed by eight nations. The buoys will be strategically de-

Photo: National Space Technology Laboratories, Bay St. Louis, Mississippi

ployed (in a zone 20 to 60 degrees south) several months before the special observing periods by ships from 14 nations—Antarctic supply ships, merchant vessels, oceanographic and fishery research ships, and so on.

The buoys (costing about $6,000 apiece) will slowly drift around 1,000 kilometers apart. They will constantly monitor and transmit sea surface temperature and barometric pressure. The signals will be recorded by the TIROS-N satellite and later tansmitted to U.S. ground stations.

Meteorological data from other sparsely covered regions, particularly south of the equator, will come from 20 or so commercial jets using a new automated system. Wide-bodied jets (all 747s) from a number of international carriers such as Pan American, Qantas, Singapore Airlines, SAS, KLM, and Luftansa will, in effect, become moving weather observing platforms.

The aircraft taking part in the Experiment are equipped with 70-pound instrument packages (developed by NASA) which accurately record wind speed and direction, temperature, and pressure at flight altitudes. Readings will be taken every 7.5 minutes, at approximately 125 kilometer intervals. The data will be transmitted hourly via a unique system called "ASDAR"—Aircraft to Satellite Data Relay. The transmissions will be received by one of four geostationary satellites and relayed to the ground almost in "real time," close to when the information is recorded.

The routes involved will take the planes over regions where there is now little weather data being collected—New York to Rio de Janeiro, Australia to Tokyo and the Mideast. The total system, installed, costs around $25,000. And when DC-10s as well as 747s are certificated to carry the unit, a great number of aircraft could become automated, mobile weather observing platforms.

Meteorologists are also capitalizing on the Aircraft Integrated Data System, already carried by more than 80 wide-bodied jets on international routes. The so-called "AIDS" system precisely records a wide range of engineering information, including wind and temperature values. These data tapes will be regularly collected and decoded, yielding additional information from worldwide routes.

Regional Experiments

During the year-long Global Weather Experiment, other regional experiments will be underway—focusing on major weather phenomena in several parts of the world. These more localized experiments will generate added data for the Global Experiment. In turn, they will benefit from the worldwide data since regional patterns are closely connected with global weather movements.

The central effort will be the Asian Monsoon Experiment, called MONEX. U.S. researchers, coordinated by the National Science Foundation, will join with scientists and technicians from 22 other nations (most from the Asian area) to study regional and seasonal fluctuations of the summer and winter monsoons. The experiment will take part in two phases. Before the first special observing

The World Weather Watch (WWW) was launched by the United Nations' World Meteorological Organization (WMO) in 1962. This international effort is aimed at providing the global weather observations, data processing, and telecommunications needed by the 147 WMO members for both weather forecasting and research. International meteorological research is carried out through the Global Atmospheric Research Program (GARP), a joint endeavor of the WMO and the International Council of Scientific Unions (ICSU), which helps develop the scientific knowledge needed to achieve WWW goals.

A 12-member Joint Organizing Committee (JOC), set up by the WMO and ICSU, is the central scientific body that considers and endorses all proposals relating to GARP and its subprograms. The JOC also identifies and plans research to solve critical scientific problems. National GARP committees were formed to carry out JOC plans. The U.S. Committee for GARP was established in 1968 within the National Academy of Sciences' National Research Council. A year later, this Committee developed the "Plan for U.S. Participation in the Global Atmospheric Research Program." The document, which guides United States research efforts within the overall framework of GARP, both benefited from and influenced international planning. U.S. meteorological research activities under GARP are mainly funded by the National Oceanic and Atmospheric Adminsitration (NOAA), the National Science Foundation (NSF), and the National Aeronautics and Space Administration (NASA). Additional contributions have come from the U.S. Departments of Defense, State, Transportation, and Energy.

The initial research under GARP focused on the world's tropical regions. The broad tropical belt around the equator receives half of the sunshine that strikes the earth. The tropics act as the boiler of a vast heat engine, which drives the atmosphere's global circulation. The workings of this crucial tropical weather belt (and its effects on weather elsewhere) are still not fully understood.

In 1969, the U.S. carried out the Barbados Oceanographic and Meteorological Experiment. The 3-month experiment concentrated on the interaction of the ocean and atmosphere in tropical waters. BOMEX, as it was called, was followed in 1974 by the massive GARP Atlantic Tropical Experiment ("GATE"). Some 4000 scientists and technicians from 72 nations spent 100 days gathering data from a 20-million square mile equatorial band stretching from the eastern Pacific to the western Indian Ocean. The flood of information gathered by ships, aircraft, satellites, and balloons was analyzed to gain a better understanding of tropical weather phenomena.

The Global Weather Experiment, which runs from December 1, 1978 through November 30, 1979, widens the focus to cover the whole world. It will be the largest international scientific experiment ever conducted. The aim—to monitor the earth's weather for an entire year. With the most complete base of weather data ever assembled, scientists will try to assess the practical limits of forecasting, design an optimum world weather observing system to improve understanding of the planet's annual climate cycle, and gain new understanding of the atmosphere which will lead to better weather prediction models valid from one day up to two or three weeks in advance.

period, researchers directed from Kuala Lampur, Malaysia, will concentrate on the South China Sea to study the winter monsoon. After the second special observing period, they will investigate the summer monsoon, operating from New Delhi to focus on the Bay of Bengal and the Arabian Sea.

Data will be gathered by an array of research ships (also participating in the Global Weather Experiment), the geostationary and polar-orbiting satellites, and commercial aircraft. The aim is to learn more about the physical processes in the "onset" of the monsoon rainy season, develop a detailed description of monsoon circulation, and examine how sensitive monsoon circulation is to various heat sources.

A better understanding of the physical processes that bring both life-giving rains and devastating droughts to the areas is needed to improve extended forecasting. Such improvement could be vital to tens of millions of Asian farmers for whom the monsoons are of critical importance.

The Western African Monsoon Experiment, called WAMEX, has been planned to help clarify the three-dimensional structure of the African monsoon, and gain a better knowledge of how it is generated and sustained. Researchers would be studying the interaction of this phenomenon with nearby ocean areas, the subtropical Sahara desert, and the southeast Asian monsoon. They would also look at the monsoons' relationship with ultra-long planetary waves, and the desert to the north.

Scientists would concentrate on the summer rainy season, using data flowing from the Global Weather Experiment observing systems. For the African nations, the results of such an experiment would not be academic since they have recently experienced the worst drought in their recorded meteorological history.

Managing the Data

The flood of information gathered during the Global Weather Experiment by various weather observing systems is too great to be handled by a single data center. Thus, the initial information processing has been broken down among a number of international facilities. Refined data will be transmitted to World Data Centers in Washington and Moscow, and also forwarded to two major meteorological research laboratories for final assimilation and analysis—the European Center for Medium Range Weather Forecasts in Bracknell, England, and the U.S. Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, N.J. There, scientists using some of the world's largest computers will seek to answer the key questions posed by the Global Weather Experiment.

Searching for Answers

It will take months for the original data to be collected and more months will pass before the assembled information finally flows to Princeton and Bracknell, England. There, the final phase of the experiment could last several years.

How will the scientists and their giant computers answer the central questions of the global weather experiment? First, it will be necessary to "optimize" the immense amount of information, making it internally consistent. The data for each day of the one year Experiment must be checked for accuracy. All inconsistencies must be resolved. Making certain that all of the data are realistic and internally consistent will occupy the powerful GFDL computer for the better part of a year. But once the task is completed, the researchers will have the most accurate, comprehensive record of the world's weather ever assembled—more than 14 billion "bits" of information.

This data, the history of the earth's weather for 365 days, will be the yardstick against which the results of the computer experiments will be measured. Meteorologists will be able to take the data for each day, run their forecasting models, and compare the results with the actual record. They can push their forecasts further and further out in time—until the predictions become of little value.

The process will be one of trial and error, cause and effect. By pushing their forecasting simulations, the scientists can pinpoint what additional data are needed and what data are essential. And they can determine the ultimate practical limits of prediction.

They can, for example, inject new data every three or six hours and compare the results with models receiving new information every 12 hours. They can cut out certain kinds of data—satellite sounding from the northern hemisphere, high altitude tropical wind data,

Problems posed by the weather, from rampaging flash floods to searing drought, will be reflected in the data obtained by the Experiment, as better forecasting of their occurrences is to be an important fallout of the research.

Photos: Agency for International Development

and so on—and see in each case what happens to their forecast. In this way, it will be possible to evaluate each of the experiment's observing systems, determining what elements of each may or may not be necessary to produce an accurate, extended forecast. In every case, the refined weather history tape provides the baseline control data.

By running simulation after simulation, constantly comparing and analyzing, the researchers should be able to judge how dense their grid must be; how many data points are necessary in the four-dimensional (space and time) computer models. They can determine tradeoffs, as well as the margin of error that can be tolerated in various observing systems in terms of effects on forecasting. Ideally, the scientists will be able to quantify the tradeoffs and come up with a nuts-and-bolts weather observing system that will indicate what is needed for an extended forecast of acceptable accuracy—at a price the nations of the world are willing and able to pay.

Scientific Followup

The questions posed by the Experiment will not be answered immediately. Indeed, research based on the unprecedented mass of global meteorological information may go on for years. Scientists from many nations will be testing new theories, investigating little-understood physical phenomena, and seeking new understanding of how weather works. In the United States, research is being planned at Federal facilities, private institutions, and university laboratories. Some prospective experiments will last for a few months and involve a single investigator. Others will be conducted over several years by large teams of researchers.

Some scientists are interested in a particular part of the globe and will use only a limited amount of data. Others are focusing on broad atmospheric behavior and will incorporate massive amounts of information in their computer models. In each case, the researcher or researchers will have a unique store of worldwide meteorological data to draw from.

Global Weather Experiment—The Potential Benefits

The Global Weather Experiment primarily involves medium-range forecasting—from 2 days to 14 days. Thus, the results will not add much to the meteorologist's ability to predict local thunderstorms or tornados. But in broader terms, the potential socioeconomic impact of the experiment could be dramatic.

A range of industries—construction, agriculture, transportation, energy, and others—would greatly benefit from improved knowledge of what the weather would be as far as 10 to 14 days in advance. The financial savings could be enormous. For instance, in December 1968, citrus growers in Arizona and California received a freeze warning four days ahead. They were able to harvest part of their crops and take measures to protect the rest. The estimated savings came to $75 million.

Agriculture would, obviously, reap some of the greatest benefits. Farmers could better gage when to plant and harvest, when to apply pesticides or herbicides, when to schedule certain equipment, and what equipment would be needed. Irrigation needs could be calculated ahead. The overall effects would be tremendous.

In the building industry, early knowledge of the weather would make it possible to better arrange scheduling, accelerating construction and securing materials and equipment, if necessary. Airlines could map out the most efficient routes, saving fuel and time. Ocean-going ships also could plan routes that avoided heavy weather, thus reducing fuel consumption and storm damage.

Utilities could plan ahead to meet special generating requirements in case of extreme weather. They could stock up on fuel, arrange interconnnections with power surplus areas, and otherwise plan to cope with sharply increased demand. Oil companies could look ahead and ship fuel to areas facing extreme cold. They might also be able to cut down on costly storage and stockpiling.

For the general public, the benefits are impossible to calculate. But longer range weather forecasts would certainly affect millions of decisions—everything from vacation plans to lawn planting. On a broader scale, the improved understanding of the atmosphere would enable planners to better gage the actual and potential effects of pollution.

It is difficult to project what the worldwide benefits of accurate extended forecasts would be. Little economic analysis has been done. However in 1966 it was estimated that the world economy would save the equivalent of $17 billion a year from better forecasting—around 50 times the cost of upgrading and operating an improved international weather services. The savings in today's dollars would be vastly greater. □

The Troubled Turtle

By GERALD D. HILL, JR.

The turtle lives 'twixt plated decks
Which practically conceal its sex;
I think it clever of the turtle
In such a fix to be so fertile.
— Ogden Nash

Not clever enough, unfortunately. However ingenious its solutions to short-term problems the sea turtle, at least, is in a jam.

It may, in fact, be in danger of extinction.

Man has exploited the sea turtle for centuries. In addition Nature, at times, has joined with man in what appears to be an effort to wipe them from the face of the earth.

Nobody knows how many sea turtles there are, but the numbers are declining at such a rate that some of the species will be extinct in a few years if nothing is done to reverse the trend.

Historical records show great numbers of turtles caught as early as the 17th century. Up to 800 turtles were taken by one man in one month in Dry Tortugas, Fla. Off Cape Hatteras, N.C., 100 green turtles were taken per day per man. In the Cayman Islands, 1,000 to 2,000 turtles were taken in one night in 1603. Today, turtles do not occur in these areas in anywhere near the numbers that they used to.

However, something is being done, and if present efforts by the National Marine Fisheries Service and others are successful, one day the number of sea turtles may approach their original numbers.

Seven kinds of sea turtles are found in the world: leatherback, hawksbill, green, loggerhead, Kerup or Atlantic ridley, olive or Pacific ridley, and flatback.

The leatherback, the largest, grows to 650–1,200 pounds. It is found throughout the tropical seas of the world, with the largest concentration in the South China Sea. The hawksbill grows to 150–200 pounds. Little is known about the distribution or nesting beaches of the hawksbill, but it has a wide range. The green turtle grows to 250–450 pounds. It is estimated that the world population of these turtles is between 100,000 and 400,000. The largest concentration, about 100,000, is found off Queensland, Australia, with the second most abundant stock of approximately 60,000 found in the western Caribbean. Less than a few hundred are thought to nest along the Florida coast.

One of the largest populations of loggerhead, approximately 40,000, is found off the Florida and Carolina coasts, with another 30,000 thought to be in the vicinity of the Gulf of Oman in the Mid-East. The largest population of Pacific ridley turtles, 450,000, is found in the waters of Costa Rica. The Atlantic and Pacific ridleys are the smallest of the sea turtles and reach about 80–100 pounds when full grown.

Some of the sea turtles seem to have the nesting instincts similar to those of the salmon. They appear to return to the same beaches each year to lay their eggs. The green turtles can be counted among this type, while the loggerhead doesn't seem to have this drive to return to the same beach each nesting season.

Three theories concern the ability of the turtles to return to their nesting beaches. Some scientists believe they navigate by the stars. Others think they can sense the differential rotation of the earth with changing latitudes. Finally, other scientists believe they can taste or smell their routes to the nesting beaches.

Turtles coming to nesting beaches number in the hundreds. Usually during the night, they slowly drag themselves up on shore and dig large holes in the warm, moist sand with their flippers, there they lay their eggs. They cover the holes with sand and then begin their slow trip back to the sea.

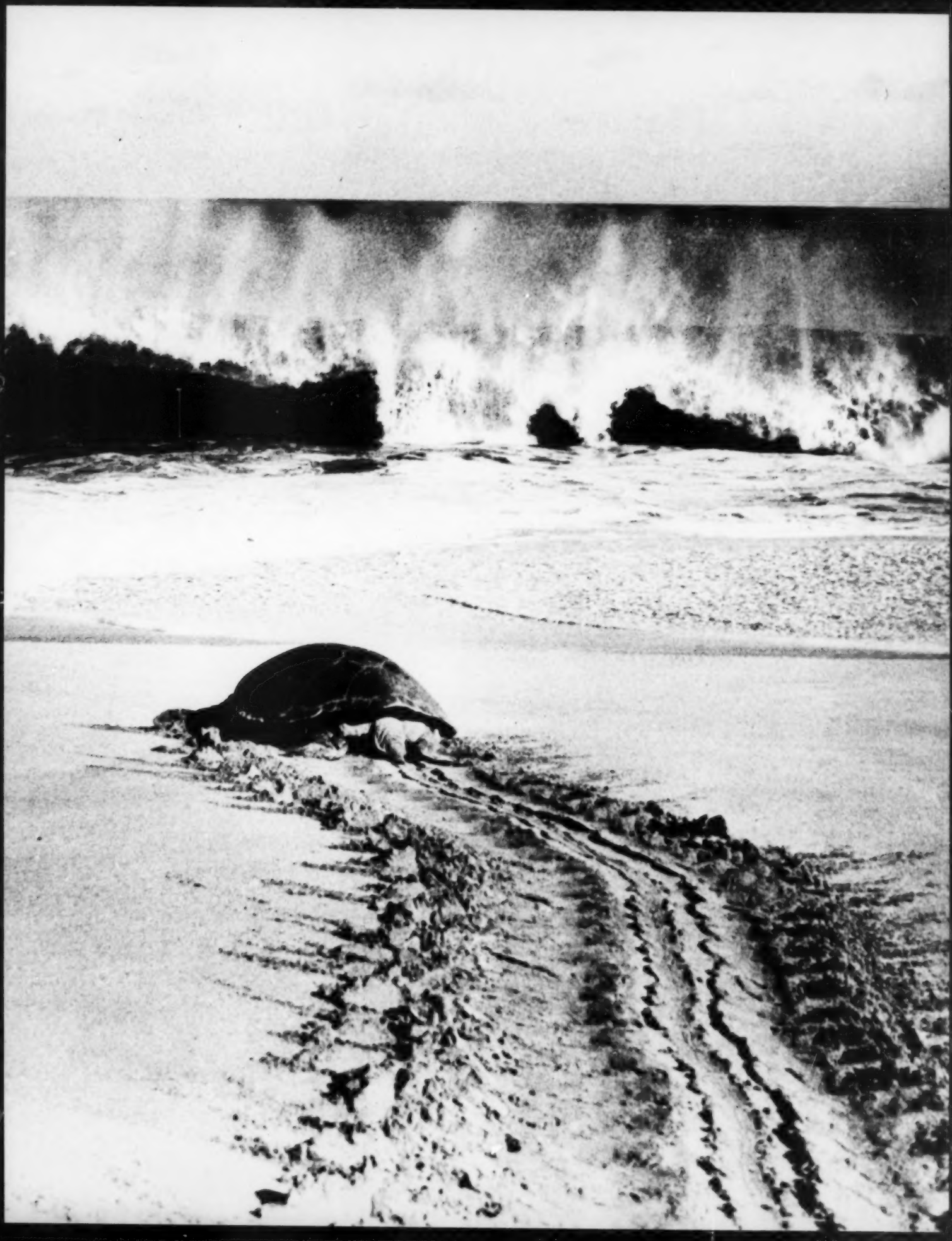
The eggs remain in the sand for approximately two months, and as they hatch, the small turtles dig themselves out of the sand and scoot toward the water. The female often lays as many as 200–300 eggs each nesting season, but all too many fail to hatch, and most hatchlings die before reaching maturity.

Nobody seems to know what happens to the turtles during their first year. Those that survive disappear for almost a year and are believed to drift to sea and live in sargassum weeds that float in large mats in the sea.

The main reasons for the decline in the sea turtle population of the world are believed to be overexploitation, loss of habitat, predation, and incidental killing.

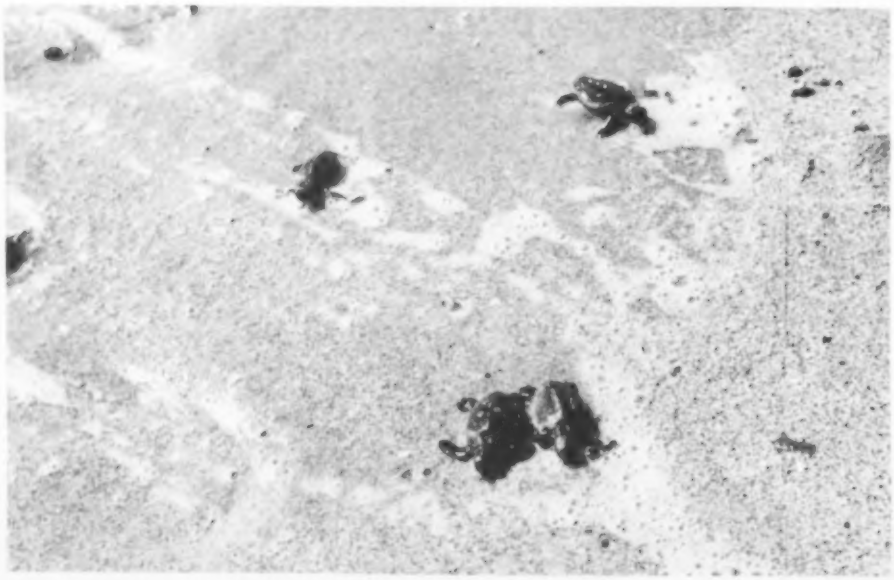
Man has been the biggest factor in the reduction of the numbers of turtles. The green turtle has been subjected to tremendous commercial exploitation. The turtle is used for meat, soup, leather, and cosmetics. Loggerheads are subject to less intensive hunting because the meat does not taste as good as the green. However, loss of habitat, predation on eggs by raccoons, and incidental drownings by fishers are believed to have resulted in the decline of this species. The Pacific ridley is hunted intensively for its leather but seldom caught for its meat. The Pacific ridley is hunted most intensely on the Pacific coast of Mexico. Scientists estimate that since the early 1960's, between 500,000 and 1,000,000 Pacific ridleys have been taken. In Oaxaca State, Mexico, in 1977, 70,000

Female turtle, having laid her eggs, works her slow way back to the sea (facing page; photo: University of Florida).



Eight-hour-old loggerhead turtles (at right and below) hatched by Nova University are released for return to the ocean. The loggerhead has been listed as "threatened" and regulations designed to conserve the species are in effect.

Photos: Ralph F. Kresge



female Pacific ridleys were killed from a population of 150,000.

Action to save these and other species is in large part dependent on the Endangered Species Act of 1973. The Departments of Commerce and Interior are charged with the responsibility of protecting endangered and threatened animals and plants.

The Department of the Interior, through its Fish and Wildlife Service, has the responsibility for the protection of sea turtles while the turtles are on land. The Department of Commerce, through its National Oceanic and Atmospheric Administration's National Marine Fisheries Service, has responsibility for sea turtles while they are in the water.

Since the law was enacted, all species of sea turtles have received some degree of protection under it. The law permits turtles to be protected in two major ways.

A species may be declared endangered or it may be declared threatened.

An endangered species is "any species which is in danger of extinction throughout all or a significant part of its range." A threatened species is "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant part of its range."

The Atlantic ridley, leatherback, and hawksbill have been listed as endangered for a number of years.

In August 1978, the loggerhead, Pacific ridley, and green were listed as threatened for all populations worldwide. In addition, the Pacific ridley was listed as endangered along the west coast of Mexico, and the green was listed as endangered in Florida and along the west coast of Mexico.

When a species is listed as endangered, it is illegal to take, transport, or trade that species with limited exceptions.

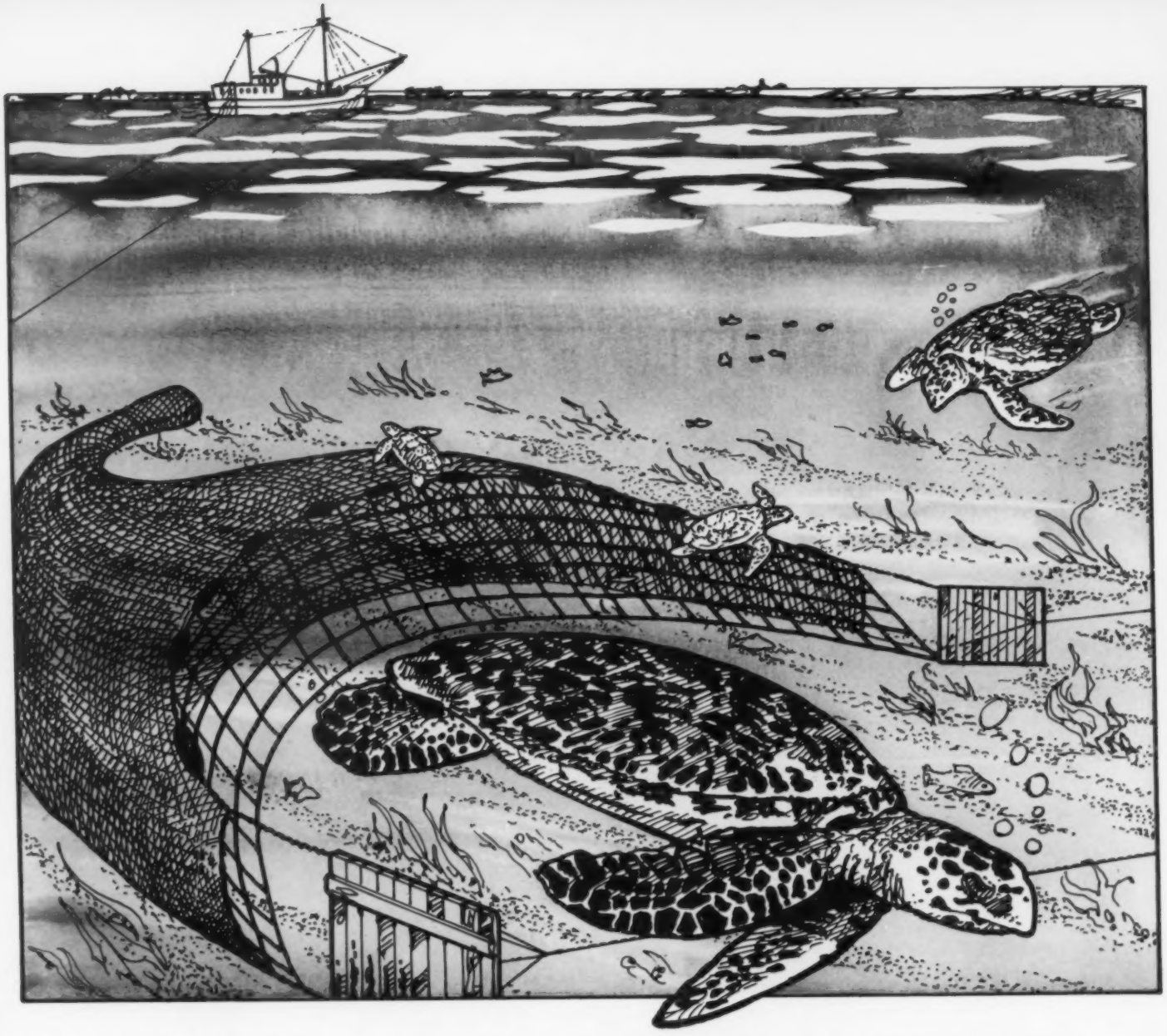
When a species is listed threatened, regulations that are necessary to conserve that species must be adopted.

One of the major threats to the loggerhead is the danger of becoming entangled in the trawl nets of shrimpers. Under present regulations, shrimp fishers are required to try to revive turtles caught in their nets by laying the turtles on their backs and pressing on their undersides until they are revived.

The National Marine Fisheries Service has been conducting tests for over a year to develop "excluder panels," and his chartered commercial shrimp vessels to support this work. The excluder panel is a piece of large mesh net that is placed across the front of the mouth of the shrimp trawl. As the trawl is dragged along the bottom, the face of the net is held open by two large wooden "trawl doors." The panel is stretched across the opening and keeps the turtles from going into the net while at the same time permitting the shrimp to go into the net through the mesh.

Shrimp vessels from Georgia and northeast Florida and the Gulf of Mexico have cooperated with the Service since the fall of 1977 in testing the panels under actual fishing conditions. Initial panel designs have been effective in reducing sea turtle capture and good progress is being made towards maintaining a shrimp catch while using the excluder panel.

Other steps are being taken to stop the de-



cline of sea turtle populations. The Service has proposed that the Cape Canaveral Ship Channel, where loggerhead and Atlantic ridleys are known to hibernate in the winter, be designated as critical habitat. Areas off St. Croix in the Virgin Islands and the Mona Island in the Caribbean are also being considered for possible designation as critical habitat.

When an area is designated a critical habitat, all Federal agencies are required to consult with the National Marine Fisheries Service or the Fish and Wildlife Service to insure that any actions they may take in the area will not destroy or adversely modify the habitat.

Because a critical habitat designation only affects actions of the Federal Government, some areas of seasonal turtle concentrations will probably have to be established under the Act as restricted fishing areas, so as to minimize further the harmful impact of fishing activities.

Information to support a proposed designation of Cape Canaveral Channel, Florida, as a Restricted Fishing Area has been obtained by a commercial shrimp vessel, chartered by NMFS to conduct turtle excluder trawl research. The vessel found loggerhead sea turtles hibernating in the Channel where commercial shrimping was occurring. Several Atlantic ridleys were also found in this area. This is the first known area of hibernation for either species. If the area is proposed as an RFA, controls could include use of the excluder panel, limitation of trawl-drag time to one hour, and, possibly, a closure of the Channel to bottom trawling during the winter months.

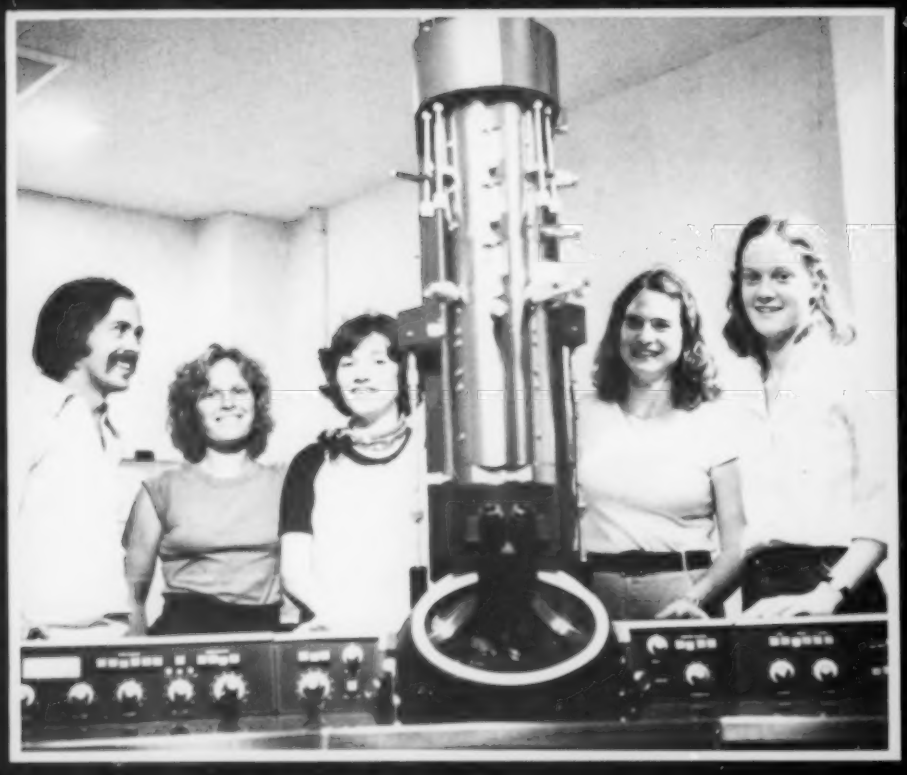
Concentrations of sea turtles have been observed off South Carolina and Georgia where shrimping occurs. However, the Service does not have sufficient information to restrict these areas to commercial shrimping at this time.

While the Endangered Species Act seeks to protect endangered and threatened species worldwide, Federal control under the Act is limited to persons subject to U.S. jurisdiction. Since sea turtles are migratory species with circumglobal ranges, management and restoration of sea turtles is an international problem. No domestic program will succeed if it does not have international cooperation.

Such an international program must encompass complementary international controls on take, commercial trade, habitat protection, research, and the reduction of incidental catch in commercial fishing operations.

The United States will seek agreements with foreign nations which have fisheries that take sea turtles incidentally to encourage those nations to adopt conservation measures, such as the excluder panel, to reduce the incidental take.

The United States is working with Mexico on a bilateral agreement on sea turtle management that could serve as a model for similar agreements with other countries. The last surviving breeding colony of Atlantic ridley turtles breeds on the Gulf of Mexico is in Mexico at Rancho Nuevo. Cooperative efforts to preserve and protect this colony have been initiated by Mexico, NMFS, FWS, the National Park Service, and the Texas Parks and Wildlife Department. Similar program should be developed for the green and Pacific ridley turtles on the west coast of Mexico. □



Standing behind the Transmission Electron Microscope, which gives them their major "window" for looking into their very small world, are the members of the Electron Microscopy Unit of NMFS' Northwest and Alaska Fisheries Center: left to right, Paul Olson, Sue Gozarek, unit head Dr. Joyce Hawkes, Carla Stehr, and Ann Kuhl.

THE SMALL WORLD OF JOYCE HAWKES

A tour by electron microscope for NOAA readers

Diagrams by Carol E. Hastings Microphotos by the Electron Microscopy Unit, NAFC

EVERY DAY, a group of marine biologists opens an electronic door to a world that is beautiful, awesome, and mysterious—a world where the very basic processes of life, death, and disease may be uncovered. In the pages that follow, the scientists will share with NOAA readers some of the beauty and mystery that they encounter each day.

Leader of the group is Dr. Joyce Hawkes, of the Electron Microscopy Unit, Northwest and Alaska Fisheries Center in Seattle. She and her assistants use both scanning (SEM) and transmission (TEM) electron microscopes to examine minute details of the aquatic environment and to apply the resulting perceptions to aquatic contamination as it affects life in the marine world. Their work, combined with research in other scientific disciplines, provides knowledge of how structural changes in animals exposed to contaminants relate to other physiological changes, ranging from alterations in enzyme production to changes in behavior.

A major aim of their work is to show which changes affect functions of organs and, eventually, viability of the species. They are supported by the National Marine Fisheries Service and by ERL's Outer Continental Shelf Environmental Assessment Program.

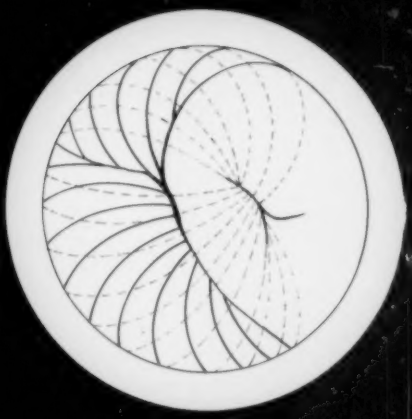
"Most of the pictures in NOAA are SEM micrographs," Dr. Hawkes explained. "They range in magnification from 20 to 5,000 times—though the upper limit of magnification of this instrument is 100,000." The images show the surface of biological samples that have been fixed, dried, and coated with a layer of gold-palladium that is only a few molecules thick.

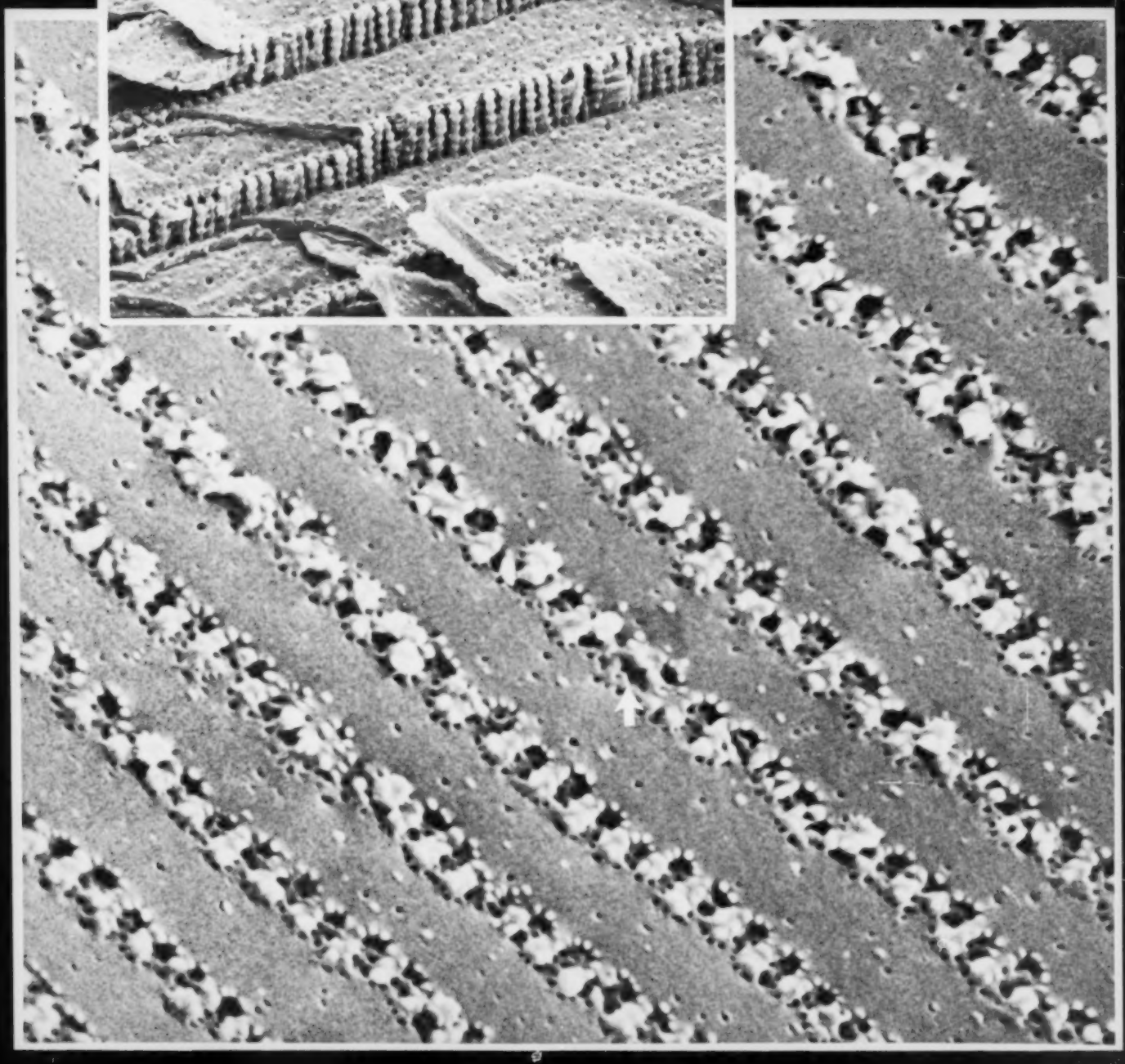
"The TEM ups the power," Dr. Hawkes said, "and can magnify from 100 to one million times. It is used with specially prepared ultra-thin sections of tissue that are only 800 Angstrom units 'thin'."

Thin indeed. A single atom measures about one Angstrom unit (A), and one inch is 245 million A wide. The TEM has a high resolution capability of from 2 to 10 A. With it, the biologists have uncovered the early effects of such contaminants as petroleum on the livers and intestines of fish. The SEM has proven very valuable in showing structural changes in fish tissues after exposure to pollutants and has been used to study cataract formation in the eyes of fish after long periods of exposure to petroleum.

Dr. Hawkes' assistants, who have helped put together the pages for NOAA readers, include Paul Olson, an oceanographer with a high degree of skill in microscopy; Carla Stehr, a fisheries research biologist who has cruised Alaska waters in search of fish embryos, larvae, and tiny invertebrates that might be affected by spilled petroleum; Sue Gazarek, a biological technician who has contributed especially to an understanding of lens changes in fish exposed to petroleum; and Ann Kuhl, a student who has spent two summers with the laboratory and who contributed the page on shrimp mechanosensory antennae.

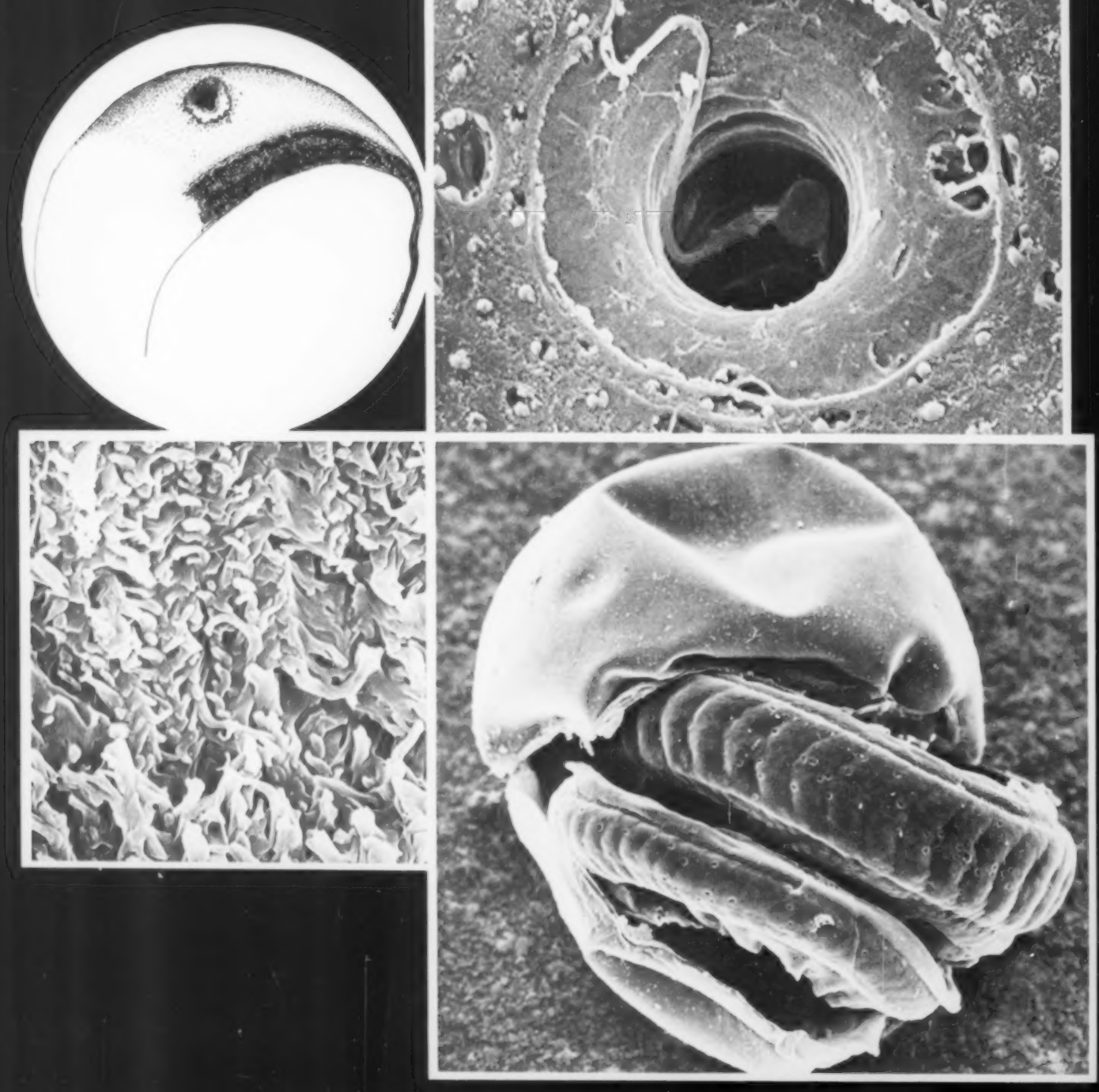
THE LENS is made up of numerous ribbon shaped fiber cells. Layers of fibers are arranged in the lens similar to the layers of an onion (diagram). There are specialized structures protruding from the fibers which interlock these cells: interdigitating, finger-like projections fit into spaces in adjacent neighboring fibers, and bumps and holes on their surface lock into the surfaces of fibers above and below (arrows). Both the morphology and arrangement of the fibers were found to be disrupted in trout which were exposed to petroleum in laboratory studies. (Background picture, 4,500×; smaller photo, 2,400×)





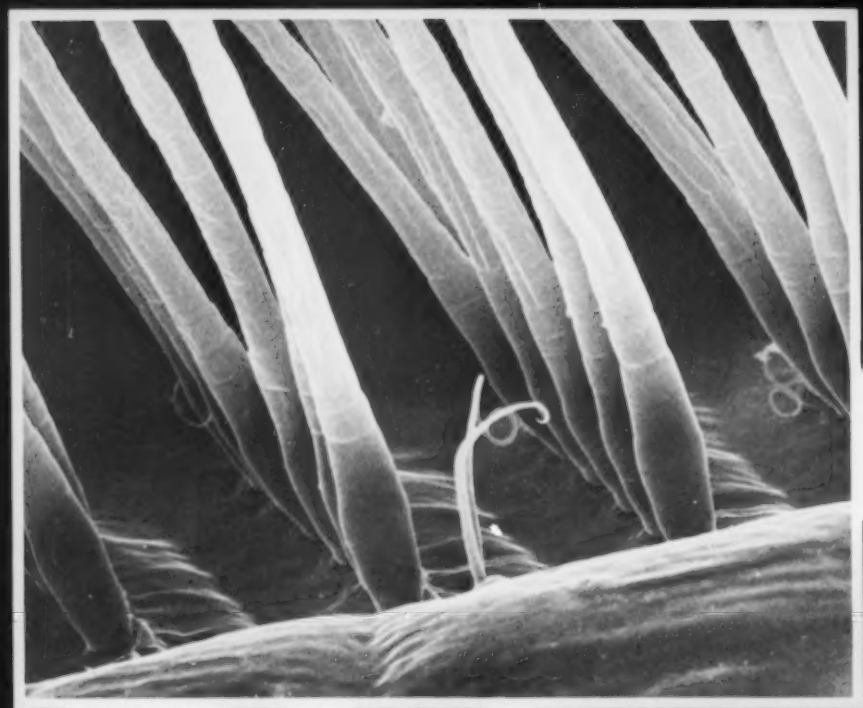
MANY FISH EGGS have a tough, outer shell that protects the egg and the developing embryo. During fertilization, sperm are not able to penetrate this shell, except through a single funnel-shaped channel. This structure, known as the micropyle, is illustrated in the diagram below. The upper right picture (5,000×) reveals a rare picture of a sperm in the micropyle during the few seconds in which fertilization takes place in a pink salmon egg. The broken edge of a pink salmon egg membrane is illustrated both in the diagram and highly magnified by the scanning microscope (bottom left, 5,000×).

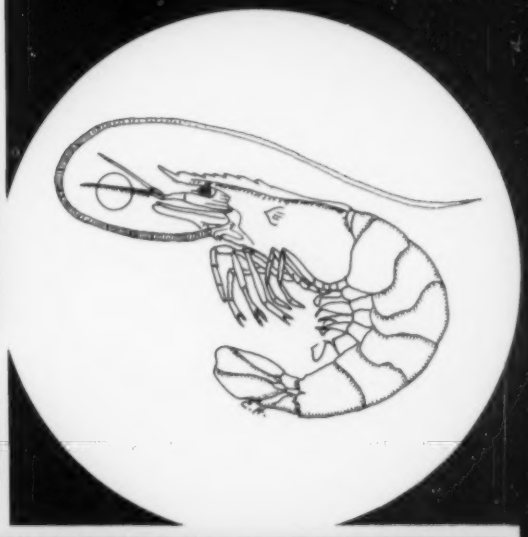
Finally, a Columbia river smelt larva was caught hatching from the confines of its membrane (bottom right, 100×).

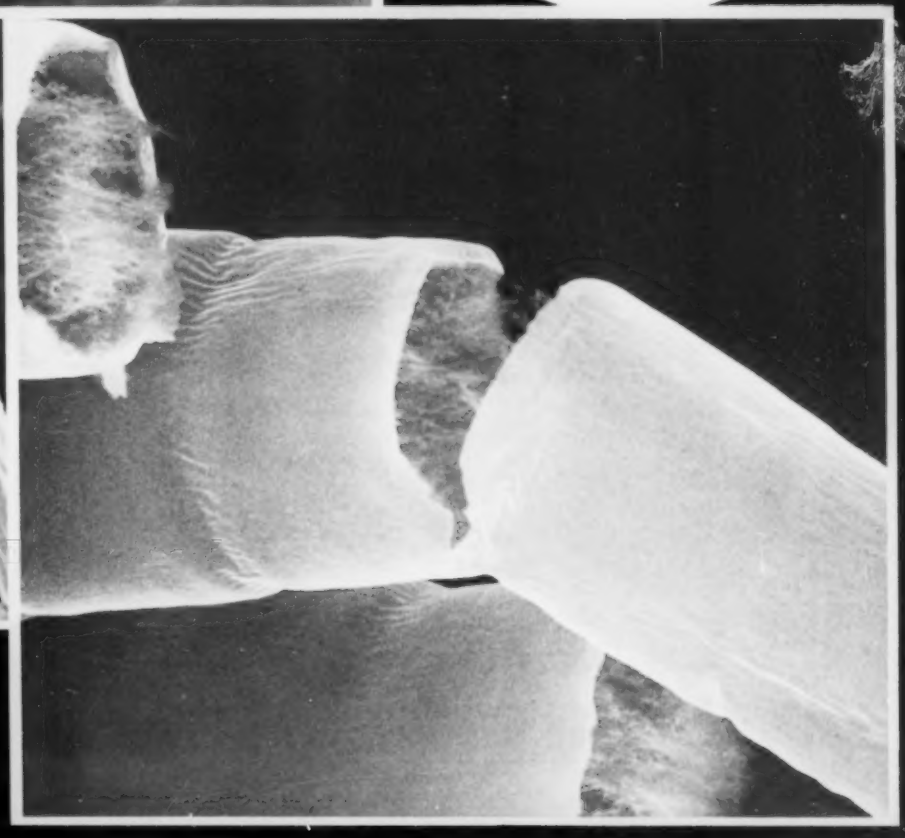


SHRIMP that live on the dim sea bottom, where visual perception is minimal, have developed a highly refined sensory apparatus that allows them to taste and smell their environment.

At top is a view of a shrimp's chemosensory hairs at 250×. The drawing shows the location of these hairs on the antennules of the shrimp (circle). These highly permeable hairs allow the shrimp to constantly "taste" the water as it sweeps its antennules about. The curled hair in the foreground is a "guard hair" which responds to touch sensations. When the hairs are broken (below, 1,660×), cellular processes (including nerves) can be seen protruding from the inner cavity of the hair. Occasionally a tiny animal called a suctorian (below left, 510×) attaches itself to the shrimp's sensory hairs for a "free ride." As the shrimp moves its antennules through the water, the suctorian may catch protozoa in its tentacles.

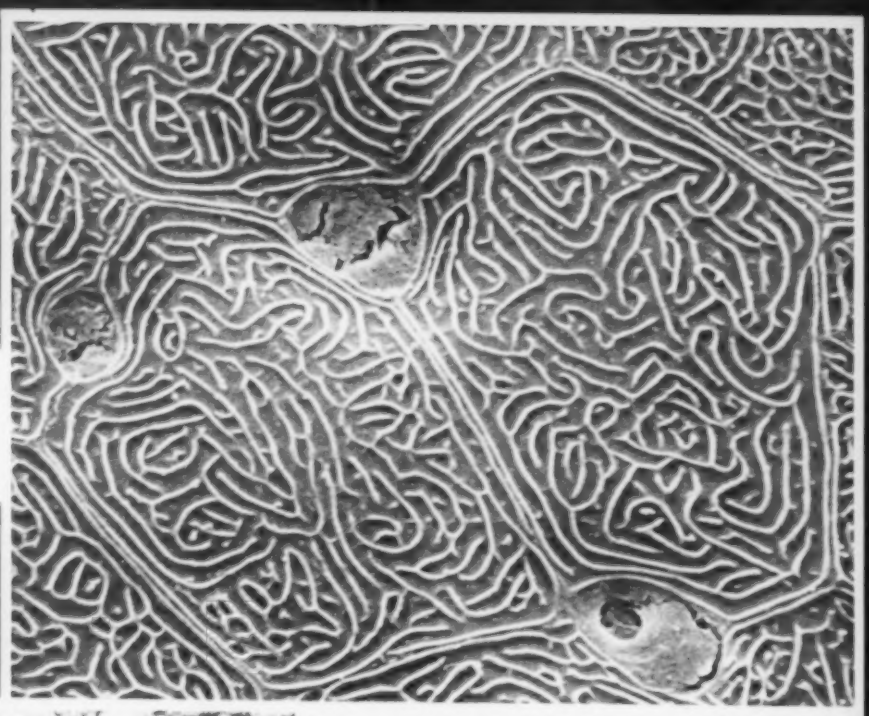


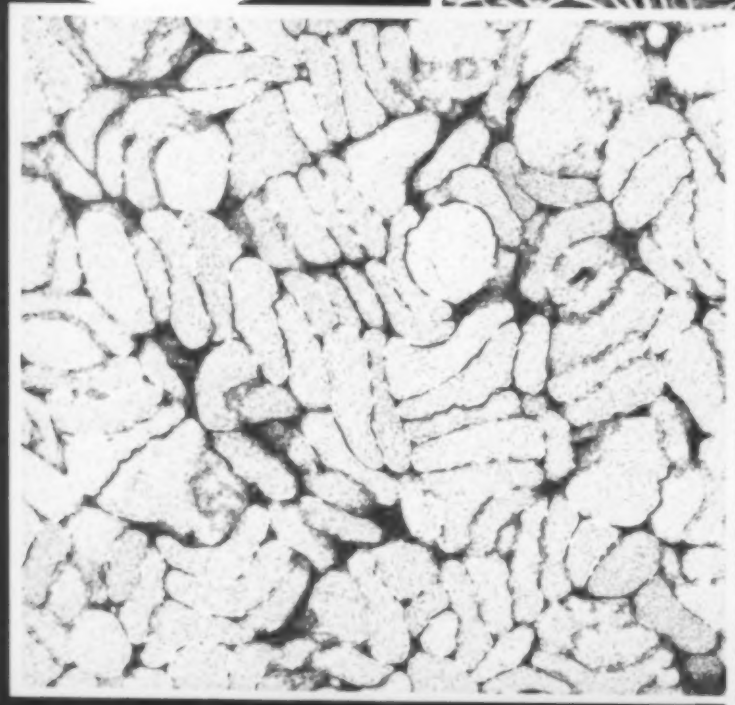


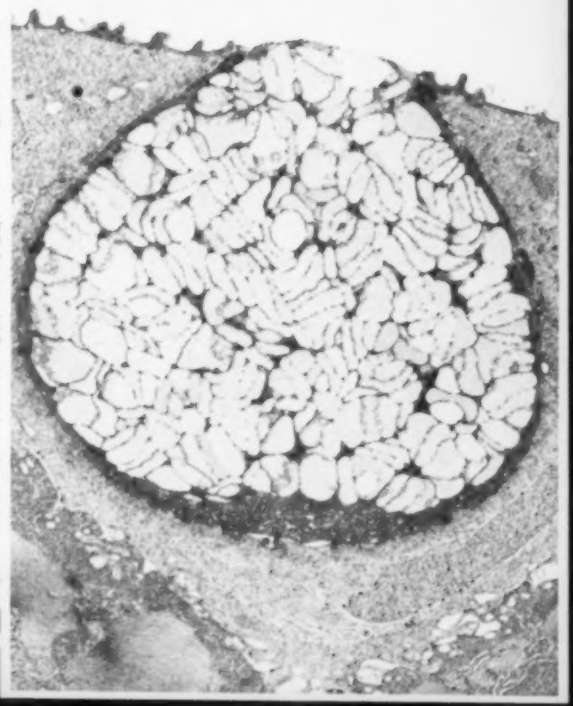


THE SKIN OF A FISH is both its largest and one of its most crucial organs. Skin protects from mechanical injury and invasion of disease-producing entities; provides lubricating substances that promote a smooth, laminar flow of water during swimming; and forms a semipermeable living surface where exchange of certain substances occurs.

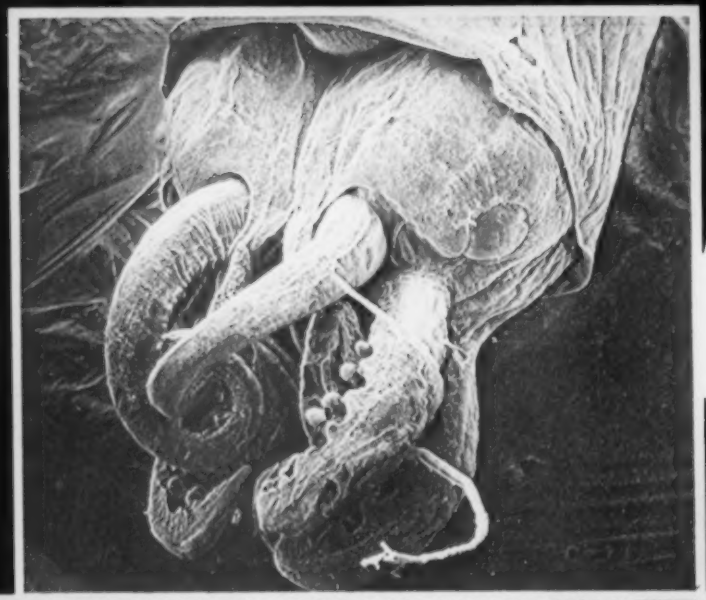
Mucous glands develop near the base of the epidermis and rise to the surface, pushing between the other skin cells. The top of the mucous gland is relatively smooth and the surrounding cells have folds in the living membrane which form ridges or "fingerprints," apparently uniquely patterned in each species of fish. Salmon skin from an area near the dorsal fin is shown with SEM on the top right (3,500×) and TEM on the lower right (6,000×). In the lower left is a highly magnified view (15,000×) of membrane-bound packets of mucous. The diagram illustrates how the surface (SEM) and the inside (TEM) views relate to the overall structure of the microridges and mucous glands of the skin.

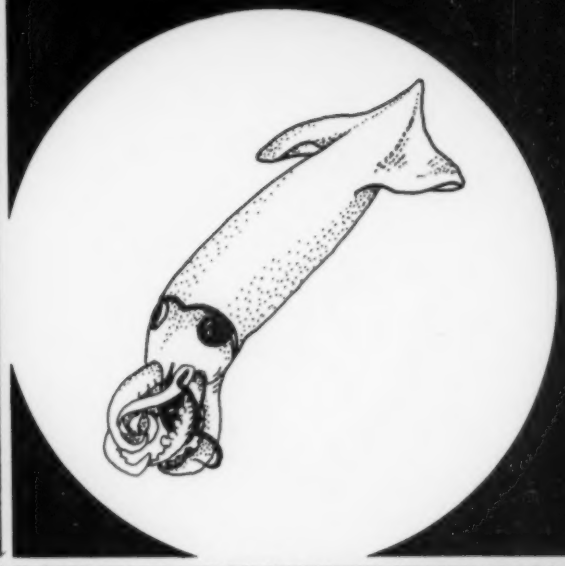


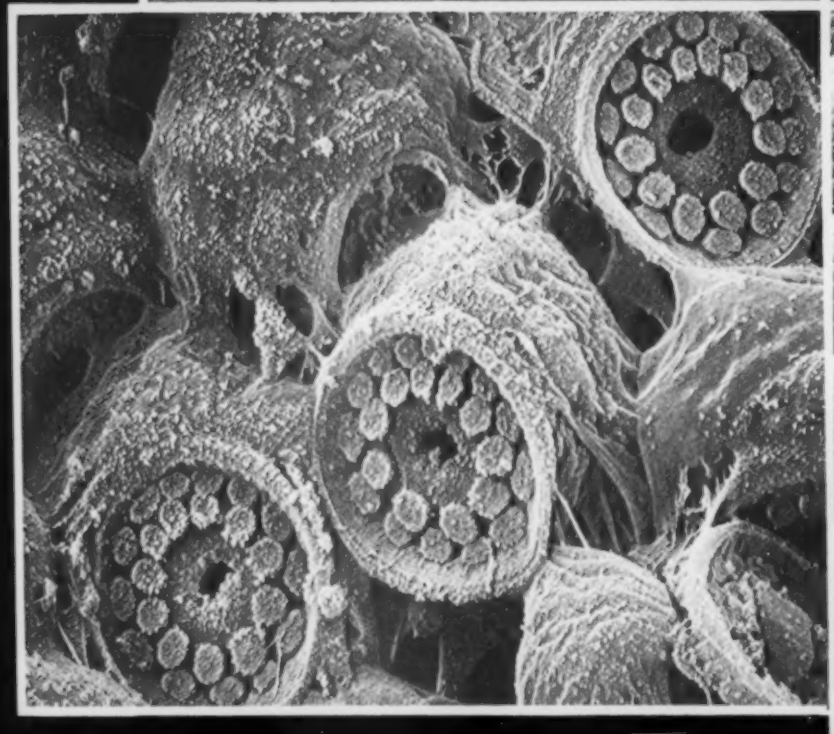


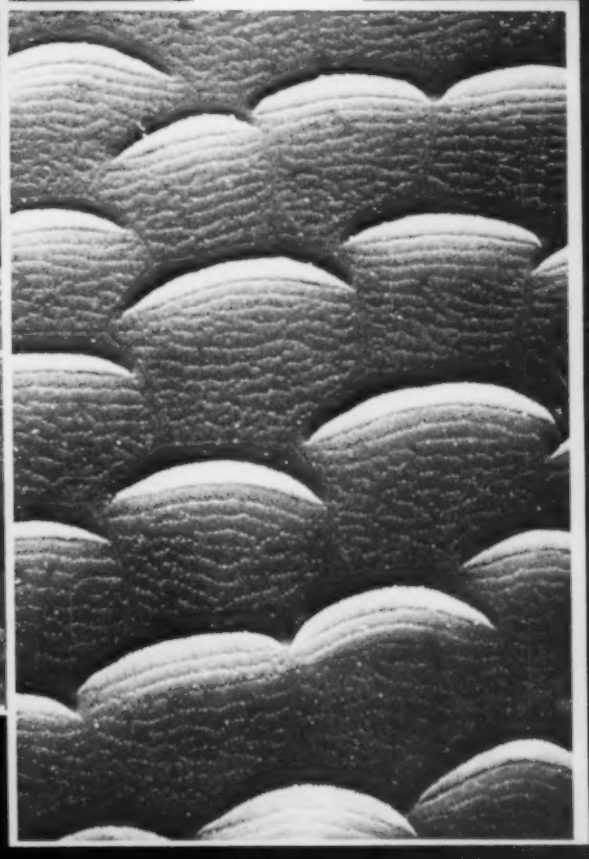


A LARVAL SQUID, one-half inch (1.3 mm) long, had captured an even tinier animal—a microscopic crustacean. The antennae of the prey and a portion of its body can be seen in the micrograph (below) and as a dark object in the diagram. The suckers of the young squid (bottom) take on new complexity at *1500* magnification which reveals rows of adhesive disks surrounding the main cavity at the tip of the tentacle. Lower right the armored pattern of the outer covering (exoskeleton) of the crustacean captured by the squid. Magnification: *2000×*.

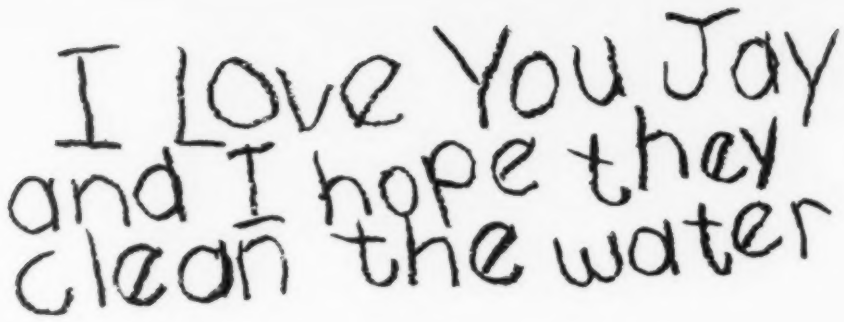








ONE WAY
If only there was school on Monday
the rain takes the river's waters and spreads them around



By BRUCE KANTROWITZ*

You might call Jay a man of letters. He opens one of his many folders and shuffles through the fan mail—

Here's one from Evelyn. She goes to public school in New York City. Evelyn is often absent from school, yet she says she has never missed a day of school until now. What she means is, when she's out of school, she has never missed it, until recently, when a day off from school prompted her letter to Jay.

Another hand-printed envelope, from Jack. Jack's no apple-polisher, either. He has always been looking for a way out. He always had a good dodge in mind. When he got out of school, Jack planned to enlist in the Army. That was one way out that he had thought of, but now he's thinking of another. It won't be an easy way out, he writes Jay, but he thinks it may be better for him.

Evelyn and Jack are just two of the 3,600 elementary and intermediate-level students in the New York public schools touched by a program called Marine Mobile.

They have never been fans of school, as any of their regular teachers will tell you. But Jay Dagress is no regular teacher. Jay is a marine education specialist, and he's not surprised by fan mail from youngsters like Evelyn and Jack.

Evelyn's letter is a complaint. Most school weeks grind by too slowly, she says, but this one has passed too quickly. It was the week Jay had spent with her class. She and her classmates, she feels, were shortchanged, but matters were out of her hands. January 2, some administrator had decided, should be a school holiday. So Jay spent four days with her class instead of the five scheduled. This disturbed Evelyn and her classmates so much that she addressed her gripe to Dagress.

"If only there was school on Monday . . . then it would be a whole week you came. But there wasn't. Eveybody, even Mr. Gottlock had fun looking at films, doing experiments, looking at turtles . . . I wish the week did not pass."

Evelyn lives in what some might call an immobile school district. As in so many inner city areas, the youngsters there never learn much about New York's waters; they're too far from the shore or their school doesn't have funds for field trips, they're told. Jay Dagress says the people who live in these neighborhoods, including the children—like Evelyn and Jack—often want to "get out" as soon as possible, out of the neighborhoods and out of the schools.

In neighborhoods like these, too often the kids lose out on subjects like marine education. Many teachers think that it is too hard to teach marine education in the classroom, so far from the hard coastal realities, so they never develop the knowledge and skills to handle those subjects. Too few teachers from too few school districts, it has been reported, attend the too few marine education workshops for teachers.

So the students never learn an appreciation for the delicate balance of marine resources, and never look to fill the jobs that marine endeavors create.

One solution for kids like Evelyn and Jack, locked into immobile neighborhoods, was appropriately called Marine Mobile. The Marine Mobile does for New York schools what Evelyn learned that the rain does for New York rivers: like the rain that takes the river's waters and spreads them around where the river itself can't reach, Marine Mobile packages marine education and takes it around to these immobile schools.

Marine Mobile is a program under the auspices of the citywide Umbrella Bureau, the New York Sea Grant Extension/Cooperative Extension (which is where NOAA comes in), and the New York City Department of Parks and Recreation.

Marine Mobile is critical in neighborhoods like Evelyn's. Though New York City has some 500 miles of coasts, not everyone lives near the coastlines; and not everyone who lives near the coast can get to the water for education, work, or sport.

A number of places have been set up around New York where Evelyn and others can learn about these waters and systems—places such as the New York City Aquarium, the South Street Seaport Museum, Orchard Beach, and Gateway National Recreation Area. But Evelyn has never visited any of these places; neither have most of her classmates.

So Marine Mobile brings awareness of water resources to them. Evelyn, Jack, and their classmates count themselves lucky to be part of this pilot program that brings a week of marine education to their school.

During that week they learn that nature has its own systems set up to recycle water. Sea Grant is teaching them about those systems. They learn, too, that Sea Grant is studying those systems at another level in universities throughout the state, and helping people who use these systems to use them wisely.

So what is marine education?

Marine education, the students learn, covers quite a lot of territory. It isn't just science;

- It can be history: learning about past uses of New York Harbor and its impact on the city's development, or learning how the harbor is used today, and how we can use it more wisely tomorrow;
- It can be art: learning a Japanese way of fish printing;
- It can be nutrition: learning about different marine foods and how they meet people's dietary needs.

Marine education specialist Jay Dagress plans the week's lessons for the pilot Marine Mobile program.

* Bruce Kantrowitz is with the New York Sea Grant Institute in Albany, N.Y.

But there are unavoidable parts of the program that are unmistakably science and students are finding these parts more fun than they'd feared. They learn about water properties such as surface tension, and they perform experiments to help gain a better understanding of these properties. They discuss ocean and wetland life, and they explore water, energy and life cycles. No program in marine education would be complete without this science component. And students find that science isn't half bad.

"Before, I thought it was junk," says Monique candidly, "but I did find it very interesting."

Jay is always glad when he gets letters like these from the students who tell him they have been listening to him. They're not always listening to the teacher, he admits. He's planned it that way. The emphasis is on learning-by-doing. So if you dropped in unexpectedly, you might find students listening to a lecture, but more likely you'd find them drawing maps of the harbor or building replicas of artifacts during the history session, making Japanese fish prints after the discussion of why fish have scales, or handling live specimens of ocean and wetland life during the biology class.

Jay says he plans the lessons as half lecture and half hands-on activity. But during some of the most popular and palatable lessons on nutrition, the hands-on plans turn to mouths-on: munching on dried shrimp, seaweed, or chocolate chip cookies made from fish protein concentrate seems to be just about everyone's favorite lesson.

It's no wonder Evelyn regretted missing one of the five days of Marine Mobile. But she wasn't the only one distressed by the day off from school. Her teacher had a similar gripe.

"We had to miss the session on history," he wrote. "I regret this . . . since it is so relevant in our area."

The 110 teachers that the program reaches are just as important as the kids to Jay. In fact, he states the objectives of the program in terms of the teachers:

- To get teachers to use the New York City waterfront as an educational resource and to realize the potential of marine education in their classrooms;

- To have teachers realize the validity of interdisciplinary teaching as an approach to learning; and

- To ignite a spark in teachers to use the world around them as an educational tool.

Because it's up to the teachers to carry on marine education after the week of marine mobile has ended, Jay has set up workshops to help them integrate marine education into their lesson plans for social studies, math, language arts, and basic science.

Learning overflows the week of 90-minute classes. Students are assigned outside work and urged to take their work home. It's not uncommon for them to share the day's lesson with the whole family:

"I tried it at home," Hector recalls to Jay in a letter. "My mother was surprised when she saw the experiment with the water and the pin.

Most of the youngsters who participated in the Marine Mobile Program live in the immobile inner city areas of New York.

Opposite page, (above) the emphasis is on learning-by-doing,hands-on activity; (below) Jay Dagress gives the students the opportunity to handle live specimens of the ocean.

And I gave the fish print to my father for Father's Day . . . He said that you sounded like a pretty good guy."

"I really enjoyed what you have taught us," Monique wrote. "You don't know how it feels to come home and tell your family all about it and they don't know about it. It makes me feel proud. I hope I have time to go the library and study more about marine biology," she adds.

Jay hopes so, too. After all, that's what he really wants.

For Jay, it doesn't end that week. For Jay there are more weeks in more schools, and more kids, and more lesson plans. For Jay it won't end on Friday, and he hopes it won't end on Friday for the Marine Mobile teachers and students. He hopes that through Marine Mobile and other marine education efforts, we will all see better use of two of our most valuable resources: our waters and our youth.

The program seems to be working. Kids who say they never liked school much are being turned on by its innovative approach. Many have already started thinking about marine-related jobs. Recycling America's youth back to its first industries, its water industries, may answer job, energy, and food shortages.

"Yes, it seems to be working," say Jay, now extending the letter from Jack.

"The neighborhood in Greenpoint, Brooklyn, where Jacks lives, produces a lot of recruits for the armed forces . . . it is one of the few ways out," Jay says. A lot of the teachers are just glad if youngsters like Jack show up at school, much less get involved in their schoolwork. But after eleven years of living in Greenpoint waiting for an out, Jack is getting involved with his schoolwork and is rethinking his options:

"Dear Mr. Jay," Jack writes, "I enjoyed the science program . . . what I liked best was the life in the ocean . . before the science program I wanted to be in the army. Ever since the science program I want to be a marine biologist."

This boy may be behind in his reading level. But Jay thinks the chances are good that his intelligence and persistance can make a marine biologist of him, if that's what he wants.

If Jack wants to do his part, then we should do ours.

Jay agrees with Evelyn and her teacher, four days aren't enough. Neither are five. It will take years of hard work to make a marine biologist out of Jack. That's why Jay and the program planners see followup as the most critical part of Marine Mobile. It's what the teachers and students do after Marine Mobile moves on that really matters.

"We don't view our program as five days of entertainment," stresses Dagress. "We are not an educational sideshow. We are trying to supply the motivation and impetus to teachers and students so that they will carry on themselves long after the Marine Mobile is gone."

"I hope you remember everybody's name," concludes Evelyn. "My name is Evelyn Jimenez."

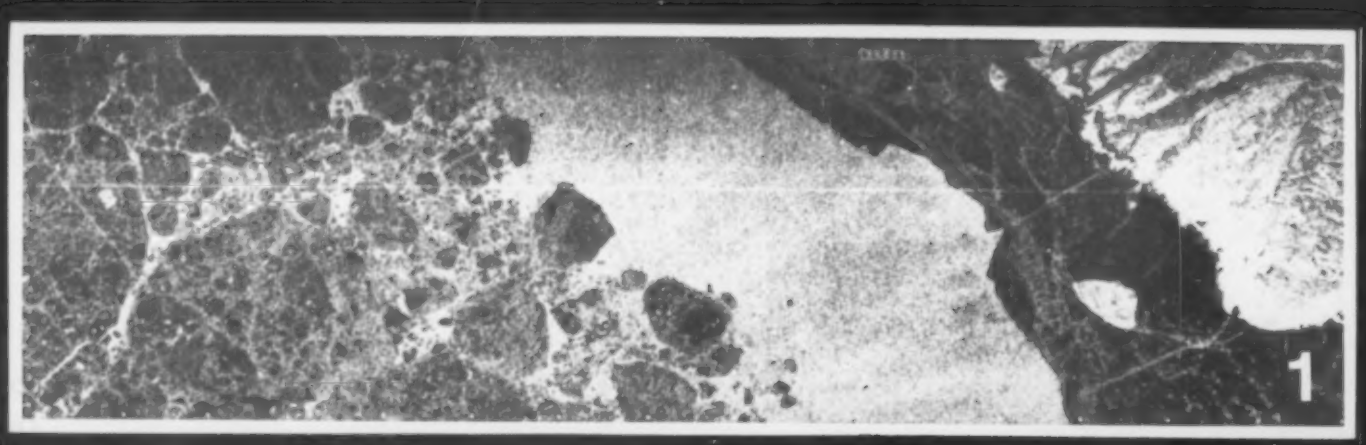
Jay is first to admit he may forget the names and faces: but that's not his job to remember. It's his job to make *them* remember. And he's confident some will.

"Dear Jay,

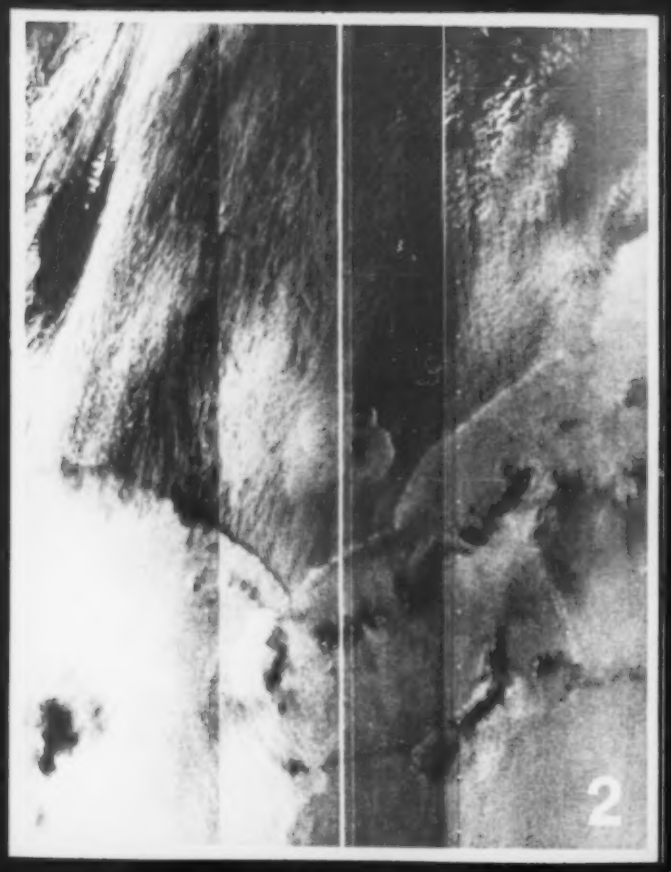
"I enjoyed your coming. I hope you come next year and stay for one month. I liked the fish printing and my mother and my father liked it too. And I also liked the food tasting. It was good. I liked when you taught us about adaptation. I also liked the three kinds of turtle. I still remember their names, the diamond back terrapin and snapping turtle and mud turtle. I also liked what Rick taught us of careers. I also liked the experiment of surface tension with the pin. I think we should keep the waters clean and I want to learn more about water and turtles and different kinds of fishes and other animals that live in water and I am interested in water.

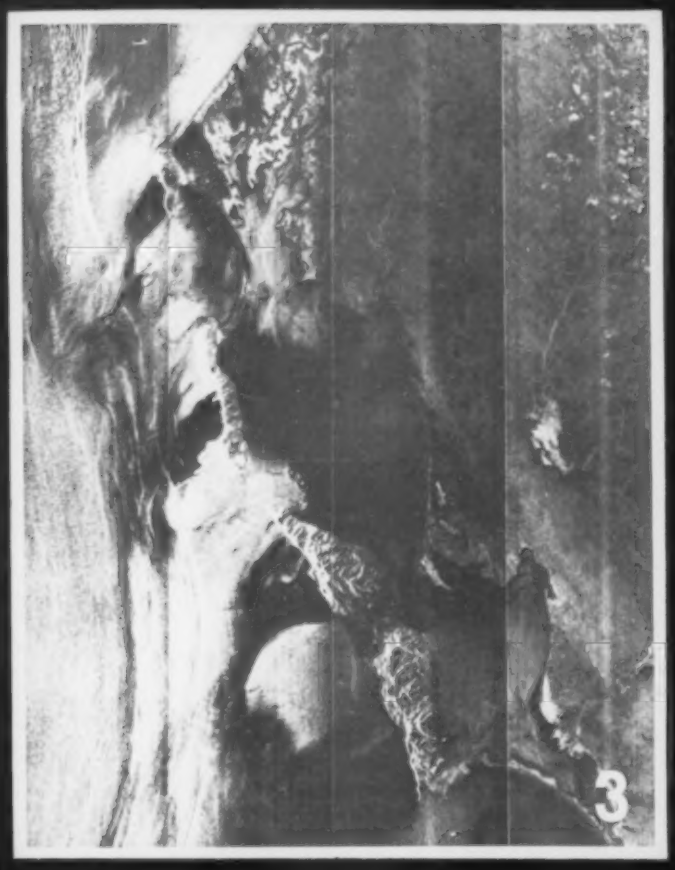
"Sincerely yours Lisa Acosta

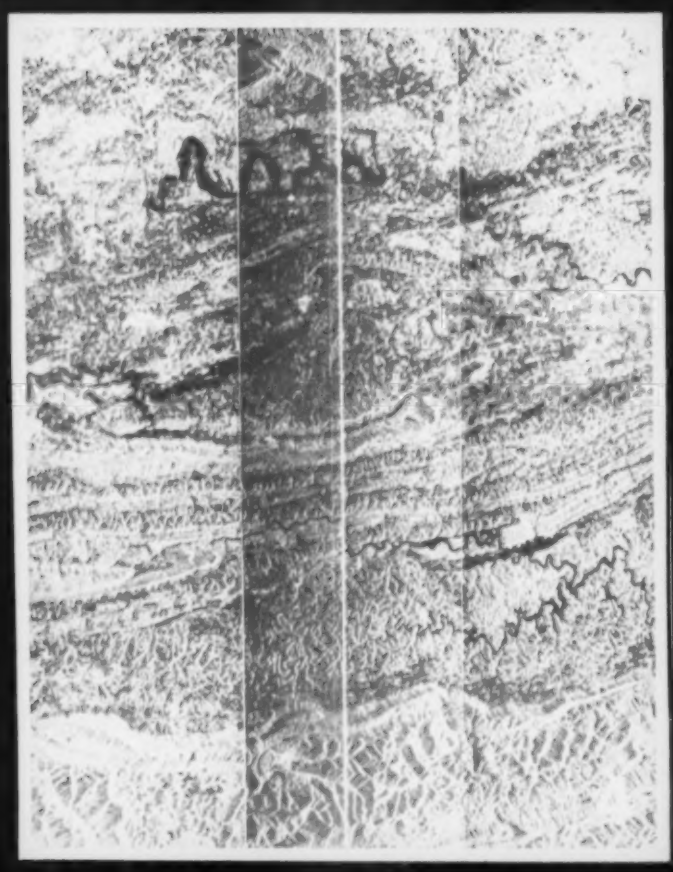
"PS I love you Jay and I hope they clean the water . . ." □



THE VIEW FROM SPACE







Seasat-A, a proof-of-concept satellite dedicated to testing instrumentation of great interest to oceanographers and others in NOAA, was launched this past summer by NASA and for almost three months returned imagery and data to earth. In the fall, however, a short circuit on board halted all transmissions from the satellite. During its brief lifespan, Seasat-A obtained Synthetic Aperture Radar imagery of considerable interest to the ocean community, a few samples of which are displayed on these pages.

1 Variations in the smoothness of surface ice on the Beaufort Sea is obvious from this high-resolution image of Banks Island, Canada (right), and the ice-covered sea surface. The main ice pack, left, is separated from the island by open water and—darker appearing because it is smoother and thinner—shore fast ice, attached to the island shoreline.

2 At first glance this image appears to be of clouds and other atmospheric features. But it is, in reality, reflections from the surface of the Atlantic Ocean just off the Florida coast. The irregular pattern in the lower half of the picture—which covers an area about 60 by 75 miles—may indicate the effects of wind and rainfall on the sea's surface resulting from a local rain squall. At upper left, the pattern striations may be related to the motion of the Gulf Steam current. Ocean waves can be seen in a limited zone near a squall area in the center.

3 A radar image of the Baja California coast of Mexico (right), a chain of coastal islands (center), and the Pacific (right) shows the varied surface patterns on the open ocean, including several areas of wind-roughened surface. Wind-sheltered water between the islands and the mainland shows up black because of its smoothness. The mountainous nature of the islands is readily apparent.

4 Although primarily an ocean-viewing satellite, Seasat-A also looked at land, and this image of geologic structure and topographic variations near Knoxville, Tenn., shows three distinct types of topographic terrain: the Smoky Mountains (bottom), the folded Appalachians trending northeast (top right) to southwest, and the Cumberland Overthrust adjacent to the Appalachian Plateau to the north. Clearly recognizable are reservoirs on the Tennessee River and its tributaries.

Oil and the Strait of Juan De Fuca

By JOAN VANDIVER FRISCH

Framed by the shores of Juan de Fuca Strait and the Olympic Peninsula, an empty tanker makes its way past the bow of the NOAA ship Researcher (above). Cape Flattery light (right), on storm-lashed cliffs of Tatoosh Island, warns incoming ships of the waterway's hazards. NOAA Survey Technicians Mike Bates and Steve Mastro (facing page) prepare to launch a vertical profiling instrument in the Strait.

(All photos with this article courtesy Bill Stewart, Everett Herald, except Cape Flattery Light, US Coast Guard photo.)

WHEN CAPTAIN GEORGE VANCOUVER, the English navigator, sailed his two stately schooners into the pristine waters of Juan de Fuca Strait in the late 1700s, the strange, bird-like vessels were observed intently by startled natives hidden in the dense undergrowth along the shore. Today a different breed of vessels seeks passage in the waterway between northwest Washington State and Vancouver Island, British Columbia, Canada. They include freight-filled containerships and tankers laden with "liquid gold" from Venezuela, Indonesia, and Alaska's North Slope oil fields—a cargo that could threaten the delicate balance of nature along the lush seashore habitats and that causes mixed feelings among the present day inhabitants along the Strait.

Tanker traffic in the Strait, a major shipping route for both the United States and Canada has increased greatly over the past five years with the phaseout of crude oil supplies delivered by overland pipeline. An even greater increase will occur should Puget Sound be selected as a transhipment point for crude oil to supply the Midwest. While supertankers and other ships weighing more than 125,000 deadweight tons are currently barred from the Strait, a steady stream of medium tankers glide through the entrance between Tatoosh Island, Wash., and the rugged shores of Vancouver Island. Their destinations are the oil refineries of Anacortes and Ferndale, Wash., and at Vancouver, B.C.

Potential increases in tanker traffic through the Strait spurred the Marine Ecosystems Analysis (MESA) Puget Sound Project Office to initiate a broad study of this ecologically fragile inland estuary. Funding for a significant part of these investigations is provided by the U.S. Environmental Protection Agency and is managed by MESA, part of NOAA's Environmental Research Laboratories.

The principal purposes of the multiyear investigations are to characterize the marine plants and animals at risk from spilled oil, to determine the present levels of oil in the ecosystem, and to describe the principal processes and major pathways by which oil may move through the marine ecosystem.

As part of this comprehensive study, the Pacific Marine Environmental Laboratory (PMEL) in Seattle, Wash., began an oceanographic investigation of the Strait in 1975. The PMEL study seeks to describe the important air and water circulation transport mechanisms that might affect the redistribution of spilled oil. Supplementary information came from other MESA contractors and from detailed surveys of circulation made by the National Ocean Survey in the Strait of Juan de Fuca, the Strait of Georgia between inland Vancouver Island and the Washington State mainland, and the connecting waterways through the San Juan Islands near refinery locations.

According to Dr. Glenn A. Cannon, editor of a recently published NOAA report on the ongoing study, the primary questions that the PMEL scientists have attempted to answer are: if an oil spill occurred at some location in the Strait of Juan de Fuca or near the San Juan Islands, what would tidal currents, river discharges, and wind-driven currents do to the

oil? Would it come ashore and if so where, or would it be transported out to sea and away from the shorelines?

To answer these questions, the Seattle scientists have concentrated first on the region that forms the narrower western half of the estuary where the Pacific Ocean meets the waters of the semi-saltwater Strait and stretches eastward 56 miles (90 kilometers) to a point just west of Port Angeles, Wash. South of the entrance lie the rocky shores of Cape Flattery, the northwesternmost point of the conterminous United States. One-half mile off the Cape rises the 80-foot rock cliff of Tatoosh Island where the U.S. Coast Guard maintains an automated lighthouse station reached only by boat or helicopter. On the northern side stretch the wild and sparsely populated shores of southwestern Vancouver Island, approximately ten miles from Cape Flattery.

Preliminary findings of a 30-month study in the western portion of the Strait produced surprising and disturbing results.

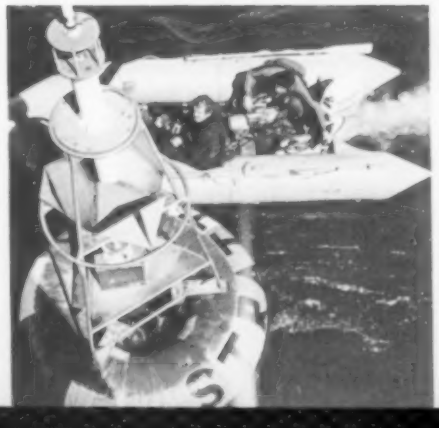
"If oil were spilled in the Strait of Juan de Fuca, there is a good possibility that much of it would likely be trapped in the estuary and would probably pollute the beaches," Cannon says. He and James Holbrook, the other NOAA scientist most involved in the comprehensive study base their conclusion on the fact that, at times, winds resulting from fall, winter, and spring storms blowing from the southwest off the Pacific coast can cause large amounts of coastal ocean water to invade the resource-rich estuary. This process actually reverses the more normal flow of surface water, which is usually toward the open sea, and instead on occasion pushes water back up the estuary as much as 62 miles (100 kilometers), according to Cannon and Holbrook. While previous experiments demonstrated that winter storms cause reversals in the flow of water at the mouth of the Strait, the more recent NOAA study reveals that the reversals probably extend much further eastward toward the broader, inner basin of the waterway.

In another series of experiments carried out during the more normal seaward flow of surface water, 5,000 bright orange drift cards released south of San Juan Island in the middle of the eastern basin of the Strait were found on all the beaches surrounding the eastern basin. However, some of the drift cards that made their way farther west toward the Pacific Ocean grounded on Vancouver Island in winter and on the Olympic Peninsula in summer, according to NOAA scientists Robert Charnell and David Pashinski. Other cards did go out to sea and some were found on Washington coastal beaches.

Satellite images of sediment suspended in water, gathered by Landsat spacecraft more than 500 miles above the earth and interpreted by Drs. Richard Feely and Constance Sawyer, showed numerous tidal fronts north and south of the San Juan Islands. Hydraulic model studies of the neighboring waterway of Puget Sound proper implied that whirlpool-like eddies exist near shore. Both of these phenomena tend to concentrate floating or suspended material such as oil.

To understand the need for such information, one must assess the Strait in terms of its resources, oceanography and meteorology, and the amount of vessel traffic that enters its rocky rugged mouth. Among its natural resources, the Strait contains a major salmon and steelhead fishery for both Canadian and American commercial and sport fishermen. Salmon and other fish seeking passage up the freshwater Northwest rivers such as the Nooksak near Bellingham and the Fraser at Vancouver, must pass through the Strait of Juan de Fuca during their journey from the Pacific. Commercial fishing ports in the area reflect such activity. In 1975, Bellingham, Wash., ranked 16th nationally in poundage of fishery products handled. Washington State ranked 10th in total poundage and 7th in total value of fisheries. The commercial value of these saltwater products at the wholesale level amounted to more than $150 million.

Other species of value to commercial fishers in the Strait of Juan de Fuca and Puget Sound include cod, flounder, sole, herring, halibut, rockfish, Pacific Ocean perch, albacore, and several types of shellfish. Commercial fishers are also pursuing several new fisheries in the region including the dogfish shark, previously scorned by both sport and commercial fishermen but frozen and processed for consumption in the Orient and Great Britain. The take of



NOAA Ship Oceanographer eases through Hiram M. Chittenden locks in Seattle (above). University of Washington technician Rick Miller (right) and PMEL summer student employee Omar Medina lower a wind recorder onto tower of a large buoy. Below NOAA divers prepare to attach underwater chain to the buoy, to anchor it on seafloor of the Strait.

Significant Shipping Accidents In Strait of Juan de Fuca, 1949–1976

Identity	Place	Date	Loss	Reason
"Anpalucia"	4 miles east of Neah Bay, WA	11/14/49	Total loss	Stranded on a rock
"S.S. Tullahoma" vs. "P&T Adventurer"	Straits of Juan de fuca, WA	8/50	1 man killed Severe damages each vessel	Thick fog
"M.S. Taikyo Maru" vs. "S.S. George S. Gratoos"	20 miles west of Port Angeles, WA	9/16/52	1 man killed Severe damages each vessel	Thick fog
"S.S. Fenn Victory" vs. "M.S. Diamond Knot"	Straits of Juan de Fuca near Sherrington Point, WA	8/13/57	$3,500,000 worth of canned salmon	Thick fog
"Chitose Maru" vs. "Marie Skou"	So. of U.S. boundary line near Wash. State	9/20/67	Very severe damage to both ships	Thick fog
"Eagle Courier" vs. "Seattle"	Off Vancouver Island, B.C.	8/7/68	1 man injured Severe damage both ships	Thick fog
"S.S. Sea Train Washington" vs. "M.S. Rose S"	17 miles east of Cape Flattery, WA	8/10 68	Severe damanges to both ships	Collision
Tank barge, Texaco Refinery	Anacortes, WA	1971	233,000 gals of diesel fuel	Tankerman error
Tank barge	Ferndale, WA	6/71	1,600 gals of Bunker C	($2,500 fine paid)
ARCO Refinery	Cherry Point, WA	6/72	12,000 gals of crude oil	Broken valve
"S.S. C.E. Dant" vs. "Aegian Sea"	20 miles W. of Ediz Hook, WA	9/4/72	Severe damages to both vessels	Thick fog
"M.S. Way Way" vs. "S.S. Oriental Mariner"	Neah Bay, WA	6/5/73	$1,000,000 damages	Collision
"Sun Diamond" (Japan) vs. "Erawan" (Britain)	Vancouver, B.C.	9/73	60,000 gals of crude oil 15,000 gals of light oil	Collision
"Lipan" (tug) vs. "Atlantic Prestige"	20 miles W. of Ediz Hook, WA	8/4/74		Collision
"Ocean Melody" vs. "Samarinda" end tape	Near Cape Flattery WA	6/17/76		Collision during thick fog

1680

urchins, the spiny, spherical creatures whose hollow shells are sold in seaside shops, expanded from 1500 pounds in 1971 to one million pounds in the late 1970s.

MESA researchers have undertaken the description of populations of noncommercial species. For example, the National Marine Fisheries Service is investigating the populations of marine mammals and the University of Washington is working with marine birds and intertidal plants and animals.

Unpredictable weather, however, is still the foe to reckon with in the Strait of Juan de Fuca. From a meteorological aspect, at least two types of weather hazards can jeopardize vessels entering the Strait. During the summer months, thick fog can blanket the region within a few minutes during early morning and midafternoon and may not dissipate for an entire day. Fog caused nearly half the major significant shipping accidents in the Strait of Juan de Fuca between 1949 and 1976.

During the winter gale-force winds often buffet the area. As a major storm approaches the Cape, ocean swells can increase to heights of 25 feet, and waves may pound the rocks from three days to one week until the storm dissipates.

Wind patterns are also complicated by the rugged peaks of the coastal Olympic Mountains on the peninsula because topography plays the major role in influencing them in the Strait of Juan de Fuca. As a result, local meteorologists are limited in forecasting for vessels approaching the coast because of the difficulty in estimating nearshore wind fields directly from largescale pressure patterns or from widely scattered and often unrepresentative wind measurements. For this reason, a numerical meteorological model was developed by Dr. James Overland of PMEL to determine regional wind patterns for an oil-spill trajectory model developed by Dr. Jerry Galt, and to explore the physical processes that create the local wind patterns. The coupled meteorological and oil-spill trajectory models were used in several case studies of the movement of oil under various wind and current conditions with the result also indicating the strong probability of floating oil ending up on the beaches in the eastern part of the Strait.

However, even poor wind assessments do not deter the number of oil tankers and other vessels entering the Strait. During the 3-month period between April 1 and June 30, 1978, 468 tankers came into the Strait bound for the inland refineries or the deep harbor port at Seattle. And the number has increased each month.

What this means to coastal residents of the peaceful shores of the Strait of Juan de Fuca is that a variety of oil and water transport processes exist which could result in considerable redistribution of spilled oil or any other contaminant throughout much of the Strait, including its sandy beaches. The evidence indicates the strong possibility of significant volumes of crude oil or other substances reaching shore within the estuary instead of being transported to sea and out the waterway as previously thought. Without such studies to alert environmental managers of the danger that lurks within the fog-shrouded cliffs of Cape Flattery, we would have little idea of the potentially devastating effects of a major oil spill on the beautiful Strait of Juan de Fuca. □

Conversation on a fascinating topic

Diving for NOAA

To millions of Americans, scuba diving is a thrilling—and growing—sport.

In NOAA, it's a way of getting a job done, and it involves several hundred men and women. As interdisciplinary as NOAA itself, diving helps the organization accomplish a wide variety of tasks beneath the ocean. NOAA divers study, among other things, the effects of ocean dumping, oil exploration and development. They take water samples to check fish and shellfish larvae, test ocean instruments, and help chart impediments to navigation; and they inspect obstructions.

Recently two NOAA divers—NOAA Corps Lt. David Peterson, the agency's assistant diving coordinator, and Barbara Pijanowski, of the Office of Ocean Engineering—talked about it on NOAA's public service radio program, "The Sea and The Air." Here are excerpts from their conversation:

Q. In NOAA, aren't the people who dive primarily scientists, concerned with some type of oceanography, rather than divers primarily?

Peterson: That's totally correct, we have no divers as divers. Currently we have 393 certified employees who dive—who are capable of diving for the agency. Not all of them every day are diving, but it's true we have no diver-divers.

Q. So, in other words diving in NOAA primarily is a tool for scientists, is that right?

Pijanowski: That's right, you use diving as just another one of the tools to accomplish your goals for whatever your projects are. In fact, that's how I got into diving. I really wasn't into diving when I first started out, but it became a necessity for one of the projects I was working on. I got into it that way, and I've been happy that I did ever since, but it wasn't something that I chose to do on my own.

Q. Of the certified divers in NOAA how many of them are women?

Peterson: There are about 30 women divers in NOAA.

Q. What is the attraction, or the fascination in scuba diving?

Pijanowski: Well, from a scientific standpoint I think that you can certainly get a lot more information as a diver on the bottom than you can from a ship on the surface, there's just different kinds of observations that you can make, when you are down there seeing what's going on. But from a recreational standpoint, I think it's probably just the fascination of being part of a different kind of world, it's peaceful, it's quiet, there's just a whole different kind of life down there; it's fascination, I guess is the biggest part.

Peterson: I agree with Barbara on the recreational aspect of scuba diving. Another attraction that I see is one of being able to put your hands on, if I may use that expression, in the water to accomplish something you wouldn't normally be able to do. There are many things that we as NOAA divers do which require us to apply a surface-oriented type of work procedure—turning a wrench—in the underwater environment and you'd be surprised at the difference in just the physical operation. You're dynamic in the water where you are static on land.

Q. Are you saying that you need to be stronger to work under water?

Peterson: No, not stronger. I think you need to be much more aware of your physical limitations that the water imposes on you. You're in a water column and your only contact is something you can hang onto.

Q. How about your first dive, Barbara; do you remember that and would you tell us something about it?

Pijanowski: It's usually a very frightening experience. I think most people have the problem. First of all, you are not used to the equipment that you are wearing, and it's very confining, in the beginning. The environment is always a lot different then you have been told it is going to be in all the classes that you have taken. And you are very much alone out there; you are not in a pool with a dozen other people at the same time.

Q. Dave, I'd like to ask you to tell us about your reaction to your first dive.

Peterson: That was very simple. I was scared to death.

Q. Why?

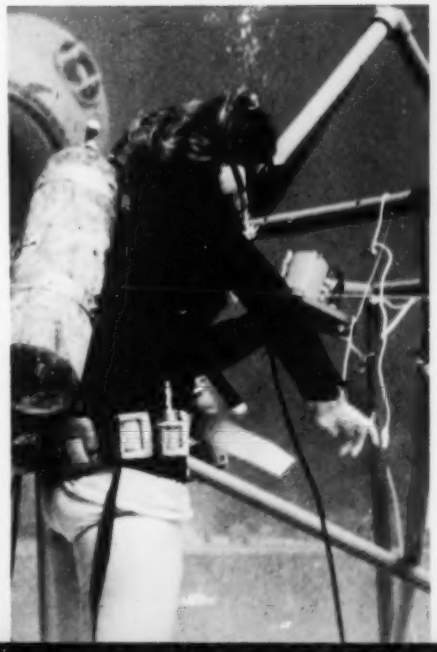
Peterson: My first experience actually in the open ocean as opposed to a pool was something I was totally unprepared for. You can learn about scuba diving in a classroom, you can practice it in a pool, you can play with your equipment in the pool under totally controlled conditions. But the minute you get out in the open ocean, like Barbara says, on your own—and you are on your own essentially—it's an experience that is a little bit terrifying until you become accustomed to your equipment and your own abilities.

Q. How about the quiet?

Pijanowski: Oh, yes, it's something that I

Barbara Pijanowski

Lt. David Peterson



Emplacing scientific instruments, measuring characteristics of water and marine life forms, seeking solutions to scientific and technical problems, NOAA divers work on a wide variety of underwater projects.

really enjoy. All you hear is the gurgling of your bubbles and it's just very pleasant.

Q. Barbara, what are some of the most common mistakes that beginners make?

Pijanowski: That's probably a better question for Dave than it is for me.

Peterson: I think the biggest mistake that a beginner can make is being overconfident. A beginner must always pay attention to his preparation, his buddy's preparation and there are many things that with experience become almost reflexive. You just do things because you don't have to think about it. But a beginner has to think all the time and if he doesn't think, sometimes it leads to an overconfidence situation, which in the water can spell trouble.

Q. But you have to have a certain amount of confidence, don't you?

Peterson: Yes, you do, both in your own ability to handle yourself and your equipment and you have to have some confidence in the people with whom you are diving. I think the best way to create a situation where confidence in yourself is justified is to start slow and build yourself up to dives of increasing difficulty or increasing depth or perhaps duration within safe time limits. And not to tackle something that you're not mentally prepared for.

Pijanowski: I think it's also important to be comfortable in the water. You should be a fairly good swimmer, at least comfortable with yourself in the water and once you're relaxed you're able to build up the confidence a little bit too.

Q. Are there any special risks involved for women divers?

Pijanowski: It's interesting that you ask that because NOAA has funded some tests, the results of which have just come in on the special physiological problems of women in diving. And I think the information that has come out of those tests (although it's not conclusive at this point it's most interesting) is that it has to do with diving as it's related to pregnancy. And it looks as though the fetus is a lot more sensitive to decompression sickness than the adult is, so I guess to make a long story short, I would draw the conclusion for myself that if I were pregnant I wouldn't dive. I think the risks would be greater than I would want to take.

Q. Animals in the sea, such as sharks and eels and jellyfish, are they hazards to divers?

Peterson: Ah—yes.

Q. You hesitate?

Peterson: I hesitate. I think the danger to a diver from marine life, like sharks is many times overstated. Certainly with the past experience to "Jaws" movies, public awareness of sharks is greatly increased. And along with this increased awareness comes the stories about close encounters with sharks and you hear a lot more about sharks than you ever heard before. No, I don't believe that sharks present a great hazard to divers. I'd be more afraid of jellyfish.

Q. Why jellyfish?

Peterson: If you get into a situation where your work requires you to dive in a fairly heavy concentration of certain kinds of jellyfish, a diver can get pretty uncomfortably stung. It's certainly not debilitating unless you happen to run into something like a Portuguese Man-of-War, but seeing things like this which cause local skin irritation, itching, burning sensations, things like that, they just aren't any fun.

Pijanowski: They're not pleasant, but they're not dangerous.

Peterson: No. Well, I'm going to have to agree with that. It's not that dangerous. No more than commonly encountered.

Q. Is pollution a threat to divers, particularly in rivers and bays?

Pijanowski: Yes, potentially it is. There is a study underway right now, trying to find out what the effects of pollution on divers are, and the kinds of immunization programs that they may have to go through in order to dive in polluted water. Unfortunately, not all of the areas that NOAA's divers have to dive in are nice clean waters.

Q. Would you tell us something about the interesting assignments that you've had in the past, or assignments with which you've been associated?

Peterson: Well, I think one of the most exhilarating, if that's the right word, experiences I've had on the job involved diving on a fishing trawl which is a net while it's actually under way and being fished. We were being towed along, two other divers and myself, on a fishing trawl which is used to catch king crabs in the Gulf of Alaska and we were being towed along at about two and a half knots taking measurements across the mouth of the nets vertically and horizontally to measure the efficiency with which the net caught crabs. But being towed through the water, just sort of hanging on the head rope and watching things fall back in the net and then actually going down and then taking the measurement across the mouth of the net was something that was a unique experience.

Q. How about you, Barbara?

Pijanowski: Well I think the most interesting diving experience I've had has been a saturation mission in one of the habitats that NOAA was using a few years ago. A saturation mission is where you and a team of divers actually go down and live in a habitat that's on the ocean floor. Your body becomes saturated with respect to the nitrogen gas that you're breathing and you stay down there for seven days at a time and then decompress at the end of seven days. It was just a fascinating experience living in an inverse aquarium.

Q. And what did you do while you were down there?

Pijanowski: Well, the purpose of the mission was to test some water quality measuring instruments that we had evaluated in the laboratory. We knew very well how these devices performed in an ideal environment and the final step in the test was to take them out in the field and find out how they performed under actual field conditions.

Q. Why would the observations be better by staying on the bottom rather than just descending for a brief period and coming up rather than going through the saturation process?

Pijanowski: Well there are certain kinds of operations and tests that are best done on the bottom. For instance, if you're working from the surface and you take a sample of water from the bottom and bring it up to the surface you no longer have the same sample of water that you started with. The pressure changes, the temperature changes—if you've got any organisms in there, the change in pressure changes the physical structure of the organisms and the chemical equilibria shift. So basically you just don't have the same sample of water that you do when it's on the bottom. So one of the advantages to working on the bottom is being able to take a sample of water wtihout having it go through all of these changes before you can run your tests on it.

Q. Can we look for any startling breakthroughs in oceanography or in the technology associated with it?

Pijanowski: Oh, there is a lot of interesting technology development that's taking place. I shouldn't say a lot—there is some. We always think there could be more. There are some very interesting things that are going on with automating the fisheries work, such as counting and sorting plankton samples automatically. The idea eventually that you will be able to tow a camera behind a ship which will automatically size and count and sort plankton which can be used in projection for fisheries stocks—that kind of thing, I think, is very exciting. That's a kind of breakthrough. There are some other sensor development type things that we're working on having to do with pollution. They can be exciting. It's just a matter of how much effort we want to put into these areas—what the output will be.

Q. Well, projecting down the road a few miles or some time, what about ocean mining? Isn't there a great deal of room for improved technology there?

Pijanowski: Yes, if you're talking about the mining of the manganese nodules on the deep sea beds, that technology is already being developed by private industry that is interested in doing the mining. They've done enough feasibility studies to know that it's possible and now they are in the course of working out the actual technical developments that they need to carry out the mining. That could be a very exciting area too.

Q. On a previous program I interviewed a gentleman who foresaw cities in the sea. How do you feel about that, or is that science fiction in your opinion?

Pijanowski: It's science fiction right now but how many other science fiction stories have come to be fulfilled in the past? I certainly think there is a possibility in the future—not for quite a while—and there is no need for it right now, but one day we will have a need, I think, and we will develop the technology that is needed, and the studies that have to be done ahead of time—I think there is a real possibility—way in the future. □

Wind-finding dropsonde dropped from NOAA research aircraft (above) radios temperature, pressure, and humidity data back to the plane, while sensing its geographic position with respect to worldwide Omega navigation system. Airborne expendable bathythermograph (below) measures sea pressure, salinity, and depth, and sends information back to the airplane.

EPOCS in the Equatorial Pacific

SOME TWO THOUSAND miles southeast of Hawaii, the NOAA ship Discoverer takes up a station where the 110th western meridian of longitude slices the Equator. Crew and scientists deploy a buoy and thousands of feet of suspended current sensors, and anchor it in the empty coppery sea. If all goes well, the floating robot will record the deep ocean's currents and countercurrents, densities and conductivities, for a year.

At that time and place, after a decade of planning, EPOCS began. EPOCS (Equatorial Pacific Ocean Climate Studies) was evolved by NOAA's Environmental Research Laboratories, and has now advanced to the stage of a major field experiment.

The key words in EPOCS are "ocean" and "climate." Funded by NOAA at nearly $3 million a year, EPOCS is the first substantial NOAA effort to comprehend the interaction of the equatorial ocean with the atmosphere on the long-term scale of climate—rather than the shorter term scale of weather, as were the concern of BOMEX and other international projects.

At the heart of EPOCS is the relationship between the ocean and atmosphere—a kind of geophysical marriage of opposites. The atmosphere is the flamboyant, active partner, with howling snowstorms and drenching rains and baking heat waves—but it has a short "memory". Nothing is "remembered" by the atmosphere more than a week or two. The ocean is the great stable partner, long of memory, given to hoarding energy which is squandered by its airy spouse. If the volatile atmosphere has 25 times the ocean's kinetic energy—the energy of movement—the ocean has four times the atmosphere's momentum, 400 times its mass, 1600 times its ability to store heat energy.

"It's become a cliché among climate people that the ocean is the flywheel and memory of the climate machine," explains Joseph O. Fletcher, deputy director of NOAA's Environmental Research Laboratories, and EPOCS director. Widely known because of "Fletcher's Ice Island"—a drifting ice floe on which he did research and which bears his name—Fletcher is a research meteorologist who, years ago, analyzed for the Rand Corporation the links between ocean temperature patterns and climate.

Reflecting on the ocean-atmosphere relationship, Fletcher said: "The ocean is so big. Any finite resource can be invested there and vanish without a trace. We would prefer to go right to the heart of the problem with our study, but that's something no one knows how to do. Still, if you look at a machine, you don't try to understand it by looking at the fan belt. You look where power is developed, how it is transmitted. You look at the most energetic parts, and the signals they reflect. So that is what we will try to do in EPOCS."

One of the more energetic parts of the ocean-atmosphere assembly in the climate machine is the equatorial Pacific, a huge and influential source of stored heat, an enormous engine for the redistribution and release of that heat into the tropical atmosphere. And this energetic part emits tantalizingly strong climatic signals. "We asked ourselves," Fletcher continues, "what the variability was—variability by year, variability by decade. Looking at it that way, it seemed clear that, on a year-to-year basis, the spatial distribution of heat released into the atmosphere appeared to be associated with large sea-surface-temperature anomalies in the eastern tropical Pacific. These are quite large, amounting to several Celsius degrees over thousands of miles, and perhaps twenty degrees of latitude. Changes on that scale could influence the global atmosphere and in any case are reflecting global scale atmospheric changes.

"Now, nearly everyone in the field has believed these anomalies were associated with anomalies in climate. But there has been little opportunity to translate this belief into numbers. We feel that by understanding the dynamics of the ocean-atmosphere system in the equatorial Pacific, we will learn what is driving what, and the sequence in which it does it. We should also learn the atmospheric or oceanic precursors of these surface temperature anomalies, and that will lead us toward learning to predict their occurrence, and their climatic side effects."

These side effects can be quite personal. *El niño* is a case in point.

Off Peru, the ocean water is normally cold, drawn from depth by coastal upwelling. The cargo of nutrients brought from the bottom to the surface, where sunlight and oxygen are available to promote ecosystem growth, has

Dr. Joseph O. Fletcher, EPOCS Director and Deputy Director of the Environmental Research Laboratories.

Dr. Uwe Radok of the joint ERL-University of Colorado Cooperative Institute for Research in Environmental Science (CIRES), who helped develop EPOCS, serves as co-chairman of the EPOCS council.

Dr. Kent Groninger, EPOCS program coordinator.

created the Peruvian anchovy fishery. The catch in good years is of the order of 12 million tons, making it the largest fishery in the world—when it is working. In Europe, fish meal from the anchovy harvest is a crucial element in livestock production; in the United States, anchovy fish meal is a nutritional mainstay of the poultry industry.

El niño—the child—is the term used by the Peruvians for the Christ Child. Because this warming occurs at Christmastime, it too is called *el niño*.

The failure of the anchovy fishery drives up the price of fishmeal, and sends parallel shock waves through the supply and pricing of substitute feed grains like soybeans. In 1973, *el niño* brought a sharp jump in meat prices, and sharpened the general perception that what appears on the family table may be determined in part by the thermal anomalies in the eastern equatorial Pacific.

"We didn't arrive at EPOCS as a shot in the dark," Fletcher notes. "It was a carefully evolved, coherent strategy to look at a highly variable, specific element of the climate problem. We feel we have enough general understanding of the mechanisms involved to be able to go forward now and probe the ocean-atmosphere system in detail. We think the problem is tractable, and believe the prospect of near-term beneficial results to be very good."

And so the EPOCS field experiment begins, probing the currents and sea-surface temperatures and boundary-layer dynamics of a rectangular area covering more than 5 million square miles of Pacific. It is 30 degrees of latitude, 15 north, 15 south, centered on the equator, and stretches longitudinally from the South America coast to 130 degrees west. To the west and north, similar activities by the National Science Foundation-sponsored North Pacific Experiment (NORPAX) complement the EPOCS experiment and, together, provide a wider view of Pacific Ocean variability.

The moored buoy set out on the equator by the Discoverer is one of a north-south array, to be deployed by scientists from the Pacific Marine Environmental Laboratory in Seattle, and capable of measuring currents down to 9,000 feet (3,000 meters). The Discoverer and, later, the Oceanographer, will revisit the buoys, in an effort to keep them operating through the year.

At the same time, oceanographers from the Atlantic Oceanographic and Meteorological Laboratories will deploy swarms of free-drifting buoys capable of reporting their position and some environmental data to orbiting Nimbus-6 and TIROS-N spacecraft.

The National Marine Fisheries Service will also expand its ship-of-opportunity program in the Pacific, providing expendable bathythermograph (XBT) recorders on the Farrell Line freighters Austral Moon, Austral Rainbow, and Austral Lightning. These ships will make two equatorial XBT sections, from Los Angeles to Samoa and from New Guinea to Puget Sound, about once every two months. About 50 XBT drops will be made on each crossing. Processing ship-of-opportunity data will be carried out by the NMFS Pacific Environmental Group in Monterey, California, in cooperation with the Navy's Fleet Numerical Weather Central.

In February, the more conventional oceanographic tools will be joined by a relative newcomer—N43RF, one of the heavily instrumented WP-3D Orion aircraft operated by the Research Facilities Center in Miami. Although best known for their research flights into hurricanes, the Orions have earned a respectable place among oceanographers, providing a unique capability for running long transects that combine "wet" data gathered by airborne expendable bathythermographs (AXBT's) with atmospheric boundary layer data from the plane's gust probe system and larger scale atmospheric data from the highly sophisticated radar probes.

For the EPOCS field experiment, one of the Orions will fly a Pacific transect after each of two intensive field phases of the Global Weather Experiment, both of which coincide with EPOCS field work. The far-ranging plane will run transects from Guam along the Equator to Majuro Atoll and Christmas Island, and then to Hawaii along the NORPAX shuttle profile flown last winter—from Hawaii to Tahiti along the 150th western meridian, dropping AXBT's every degree to five degrees north, then every half degree across the equator to five south. The flights will mix low-level boundary layer profiles at 500 feet (150 meters) above the sea, and high-level flights at 20,000 feet (6,000 meters). On especially long flights, the P3 will cruise on three engines, to make up the fuel burned on the low-level runs. Later, staging out of Acapulco, the airplane will return to the EPOCS study area for a concentrated set of similar measurements over the moored buoy array, from about 10 degrees north to 5 degrees south across the equator. The airplane will repeat these transects when it returns from the Indian Ocean after the second intensive observing period of the Global Weather Experiment in late June.

Satellites will play an important role in EPOCS. Images from NOAA's geostationary satellites will be the basis for estimates of surface winds over large areas of the equatorial Pacific. The importance of such estimates has long been recognized by scientists as fundamental to a general understanding of the momentum exchanges between the sea and atmosphere, transfer processes, and the correct interpretation of ocean-current and dynamic-topography measurements. Satellite observations provide the knowledge of global behavior within which the intensive regional studies will be interpreted.

It may be too that satellite data can be used to monitor the intensity of ocean currents. Satellite images clearly show long, westward-propagating waves along the thermal front between the westward-flowing south equatorial current and the warmer eastward-flowing equatorial countercurrent. These waves are believed to be caused by an instability resulting from the large shear between these currents. If this is true, the characteristic period and wavelength must be related to the currents, which can then be inferred from satellite observations of the waves. EPOCS will test this theory, which was developed at the Geophysical Fluid Dynamics Laboratory at Princeton, and help define new mathematical simulation experiments at the Princeton facility.

A new technique for estimating rainfall from satellite images, pioneered by scientists from the National Hurricane and Experimental Meteorology Laboratory in Miami, will also be applied in EPOCS. Because most of the heat added to the atmosphere is carried in water vapor from the sea—and released as heat of condensation when the vapor condenses into raindrops—variations in the distribution and intensity of tropical rainfall are important to understanding climatic responses at higher latitudes.

Rainfall is also one of the signals of a warmer or colder ocean. When sea surface temperatures are warmer than surface air temperatures, the lower atmosphere is destabilized, with an accompanying dramatic rise in rainfall.

The satellite rain-estimating technique has been applied successfully during NOAA's cloud seeding experiments in southern Florida, and has entered quasi-operational use by flood forecasters trying to anticipate whether an approaching hurricane will be relatively wet, or relatively dry. In EPOCS, it may provide a link between the hydrologic cycle of the tropics, and climatic fluctuations farther north.

The field experiment is only a part of EPOCS. While it is under way, EPOCS people are also drawing together the large data sets already in existence—data sets in which NOAA scientists have begun to identify the correlated air-sea signals of the equatorial Pacific and higher latitudes. Recent, and still preliminary, findings by Fletcher, for example, show strong climatic signals. "It looks like somebody threw a switch," says Dr. Kent Groninger, who will coordinate the EPOCS program. "You get suspicious that what you're seeing is an artifact, something wrong in the data, rather than nature. But there it is."

Data sets that are finely enough resolved to show such signals are only just becoming available from NOAA's Environment Data and Information Service, and are a centerpiece in the EPOCS studies.

A third element in EPOCS, as in all modern environmental studies, is numerical modelling and analysis. Here, EPOCS scientists will incorporate new data from the field experiment and other sources into existing ocean-atmosphere numerical models. They also expect to gain a better understanding of the important physical processes operating in the equatorial region, and to develop new models capable of expressing—and, ultimately predicting—those processes.

"In designing EPOCS," Fletcher says, "we tried to make our approach faithful to the problem. EPOCS is primarily an oceanographic investigation, but it requires great balance on the atmospheric side as well. It's highly focused, very specific, and deals, we believe, with processes we can learn to understand over a reasonable period of time."

What may seem an elaborate management scheme is intended to hold EPOCS on its highly focused, multiyear course. While Fletcher will direct EPOCS, he will do so in collaboration with two vital bodies. A seven-member EPOCS Council, selected from among the principal investigators to represent the varied oceanographic and meteorological research elements of EPOCS; and an EPOCS advisory panel, consisting of as many as a dozen senior scientists, will provide additional scientific expertise on equatorial climate dynamics. This panel will be made up mainly of scientists from outside NOAA.

There is another aspect of EPOCS. As NOAA's leadership role in the National Climate Program takes form, EPOCS is the first major climate study mounted by the agency. It should set important examples for the climate studies to come, and will be a vital training ground for those who would devise ways of probing the long temporal curves of ocean, atmosphere, and climatic change—epochal dimensions echoed in the name of the experiment. □

Ocean field experiments such as EPOCS are able to take advantage of the great number and variety of oceanographic platforms and instruments now available.

ERL CO-OP Program Opens Career Doors

Toward a Brighter Future

WHEN MARY CAIRNS answered a long-distance telephone call from Lois McCoy, Coordinator of the Environmental Research Laboratories' Cooperative Education Program (CO-OP), the news she received changed the course of her life. Discouraged with her studies and the lack of job opportunities, Cairns, a San Jose State University sophomore meteorology student, was planning to quit school after her final exams. NOAA's CO-OP job offer changed her mind and opened a career door that may otherwise have been locked indefinitely.

"CO-OP gives college students a chance to put their major subjects to work in a very positive environment," said McCoy, who holds a B.A. in psychology from the University of Redlands, and an M.S. in counseling and guidance from California State University in Los Angeles. "We're interested in developing the potential of students such as Mary Cairns because we realize the payoff to NOAA."

The 4-year-old cooperative education program is designed to provide the laboratories with a continuing source of under-graduate students who can be trained and retained in professional administrative, scientific, and technical careers.

Students in the program alternate periods of full-time work at ERL with related study in educational institutions that have formal agreements with NOAA.

The purposes of the program are to build a strong, well-balanced work force and to maintain effective relationships with colleges and universities, which will be the chief source of future scientists, engineers, and professional administrators.

To date NOAA has entered into formal CO-OP agreements with more than 60 colleges and universities from 25 states and the District of Columbia.

When a particular laboratory or program area within ERL has a position open that a CO-OP student could fill, McCoy begins the recruitment process. After thoroughly investigating the needs of the laboratory and its position qualifications, she selects a college or university near the NOAA facility that is most

Co-op Coordinator Lois McCoy chalks up progress for one of the 100 students now working in the ERL program, before leaving on another recruiting trip.

likely to provide a relevant major. If no educational institution with a degree program in that field is near, McCoy selects a school that is within a reasonable distance and that has a strong department in the appropriate field.

"For example, several laboratories around the country need students majoring in meteorology, the science of the atmosphere, and specifically, weather and weather forecasting," she said. "However, the closest institution with a good undergraduate program in meteorology that fits our needs is San Jose State University in California." As a result most meteorology students working in ERL's Boulder-based laboratories and field laboratories such as the National Severe Storms Laboratory in Norman, Okla., are recruited at San Jose State.

At least 1,000 schools have bona fide CO-OP programs throughout the U.S., according to McCoy. Using a catalog that lists the various institutions and programs, she works carefully to match the needs of individual ERL laboratories with the students in the differing majors.

She also weighs the success of affirmative action programs at educational institutions under consideration. "Some universities do not recruit minorities," McCoy said. "When looking into the record at one school, I found that out of 400 students, only eight represented minorities, and only 50 were women." As a result, she decided that ERL would not work with that institution. To determine their relative affirmative action success, McCoy uses other resource material which lists how many women and minority students are enrolled at the particular school.

McCoy belongs to the National Cooperative Education Program Association, whose members she can consult for recommending good programs at other institutions.

After selecting the school that has the best program for ERL's needs, McCoy talks with the CO-OP coordinator at that campus and, if possible, visits the institution to cultivate cooperation with the university. To accomplish her recruitment task, she spends about one week per month during the school year on college campuses throughout the United States. Currently, McCoy is actively recruiting students from 19 college campuses from New York to Florida, and from Texas to Washington. As of January 1979, she will have 100 students participating in ERL's CO-OP program, working alternate schedules at 13 laboratories or program areas around the country.

To help McCoy match prospective CO-OP students with the laboratories, ERL's Administrative Council, consisting of the senior administrative officer in each laboratory and program area, acts as a liaison between the laboratories and program areas, encouraging them to participate in the CO-OP program.

After a student has been offered a specific job with one of the laboratories, he or she works out a time schedule with McCoy. "All federally employed CO-OP students must have completed two work periods, usually lasting one summer or semester each, before graduation," McCoy said. Because many of the students enter the program as juniors, their graduation is deferred a minimum of one semester, often a full year. A few of the students have asked to work for 1 year periods

San Jose State University student Michael Dias changes chart paper on a microbarograph as part of his work with the Atmospheric Physics and Chemistry Laboratory "weather room".

Mary Cairns, a Co-op student at the Wave Propagation Laboratory, confers by telephone on wind shear information at Chicago's O'Hare and Washington's Dulles airports.

not interrupted by school, but these requests must be approved by McCoy, the laboratory, and the college or university involved.

And the ERL CO-OP system is reaping benefits from its success.

"We've been recognized by the Civil Service Commission in San Francisco and Washington, D.C. as having one of the finest examples of government CO-OP," Mccoy said. As a result she has been invited to give workshops with the Civil Service Commission on how to set up successful CO-OP programs.

One of McCoy's innovations is having senior students give scientific seminars on research they are doing at ERL facilities.

"Mary Cairns, one of the first students in the program, gave an excellent scientific seminar concerning her research on wind shear events from O'Hare and Dulles International airports while she was working with the Wave Propagation Laboratory's Atmospheric Studies group," McCoy said. Cairns was president of the local American Meteorological Society chapter at San Jose State University; after finishing her studies there in December, she was offered a permanent job with the laboratory in Boulder, Colo.

"I really valued the CO-OP experience, because it gave me a chance to contribute something," Cairns said. "And it gave me a work experience opportunity that could not be derived from a book."

McCoy also meets with the CO-OP students at the ERL facilities in Boulder once a month.

"These monthly meetings accomplish several purposes," she explained. "They provide a format for student seminars, set the stage for solving problems between students and supervisors or laboratories, and given them needed moral support and advice."

Not all ERL CO-OP students are majoring in meteorology. The program also includes college sophomores, juniors, and seniors who plan careers in computer sciences, biology, chemistry, engineering, or physics.

For example, Mark Hall, 19 years old and a mechanical engineering major at Tennessee Technical University in Cookeville, has spent the past year working with scientists at NOAA's Air Resources Atmospheric Turbulence and Diffusion Laboratory in Oak Ridge. He has calibrated instruments and operated cameras for time-lapse photography as part of wind tunnel and field tests of smoke pattern circulation around power plant cooling towers, including the Widow's Creek Steam Power Plant in Alabama.

"The CO-OP experience has really been beneficial for me," Hall said. "It has given me an idea of what I should expect in terms of job opportunities when I finish school, and why some required courses, which I felt were unnecessary, are important."

Pam Porter—a senior at the University of Wisconsin at LaCrosse and a chemistry major—became part of ERL's CO-OP group at the Aeronomy Laboratory in Boulder and is studying the collision processes in the upper atmosphere by simulating them in the laboratory.

"CO-OP is exposing me to the equipment and facilities that I believe a chemist would need to know about to conduct good research," she said. "Many chemistry students don't think electronics is particularly impor-

Gwen Lowery from San Jose State University holds a photometer, measuring the amount of sunlight loss in the atmosphere, as part of a study by the Atmospheric Physics and Chemistry Laboratory on Cedar Mountain, Utah.

Tennessee Technological University student Mark Hall calibrates hot-film anemometers to be used in the wind tunnel at the Atmospheric Turbulence and Diffusion Laboratory.

tant, but a person who doesn't know how a machine works can destroy the machine and the experiment."

NOAA's cooperative education program also helps students define their career aspirations and helps them mature in the process, McCoy said.

For example, Michael Dias, a 22-year old senior CO-OP student from San Jose State University, first came on board three years ago at ERL's Atmospheric Physics and Chemistry Laboratory, looking at air pollution samples and snowflakes with an electron microscope. He also spent one summer at Price, Utah, operating a variety of meteorological instruments as part of a field experiment studying air quality near a fossil-fuel power plant.

After completing his junior year in meteorology, he asked to transfer to another group within the same laboratory so that his work would be more directly related to his major. As a result he is now in charge of operating the weather forecasting room at the laboratory, plotting twice-daily balloon soundings from Denver, and maintaining a variety of weather instruments, facsimile, laserfax and teletype machines, which are used by scientists at ERL. In addition, Dias has his own research project—performing a major analysis of a flash flood that occurred in Los Angeles in the spring of 1978.

"Having the opportunity to participate in a field experiment gave me a much better idea of where I wanted to go in my career," said Dias. "It enabled me to find out, before graduating, what I wanted to do. For example, I found out that I wasn't very interested in air pollution, but much more interested in mesometeorology."

Students such as Dias, Cairns, and others who complete their CO-OP work-study experience have an additional bonus when they graduate. At that time they have for 120 days an opportunity to accept a career-conditional appointment with NOAA in which they do not have to compete on the Civil Service register.

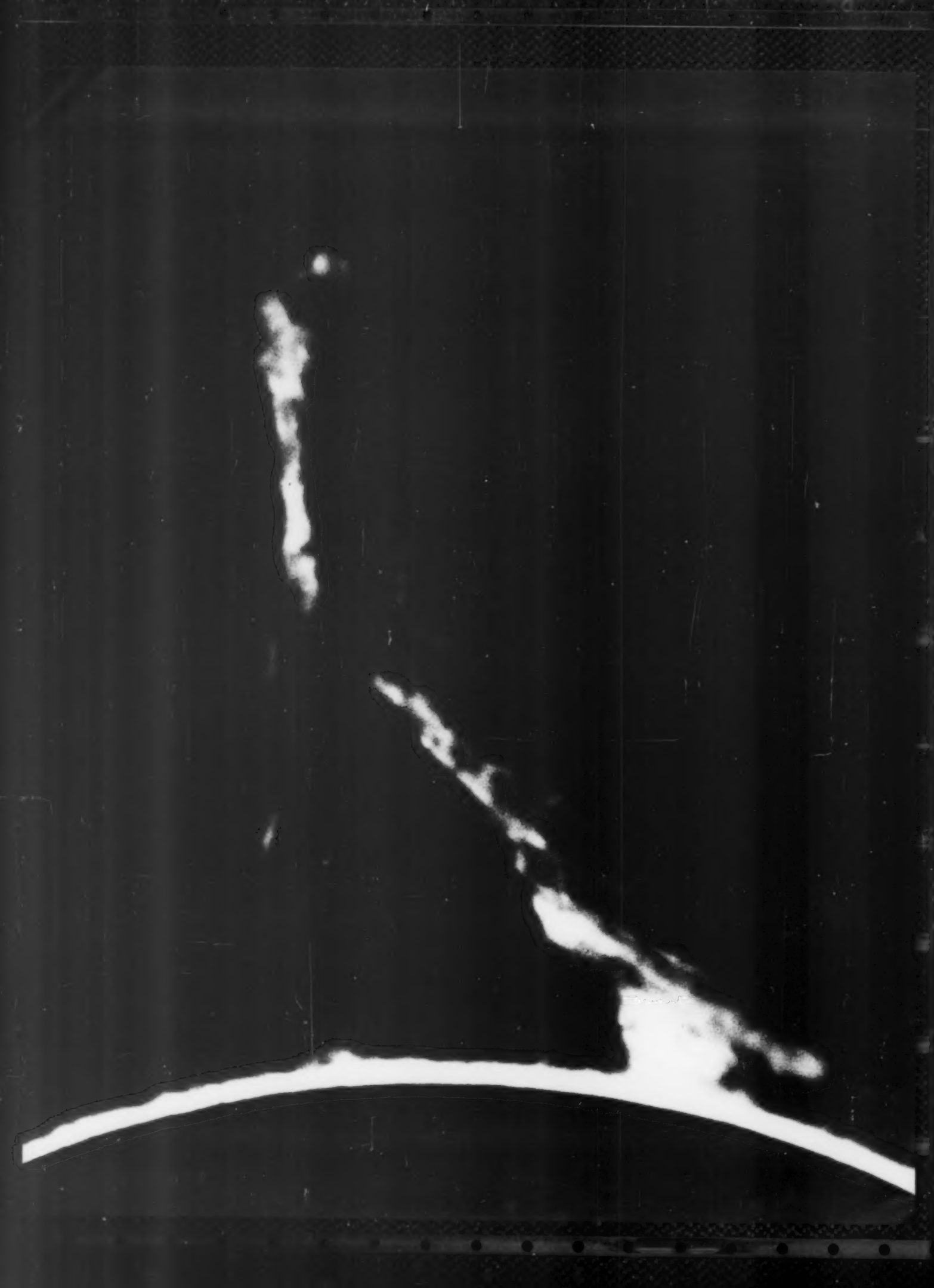
"So far 12 students have graduated from the CO-OP program with ERL," McCoy says. "Of those, nine have been converted to career-conditional appointments, which is a 75 percent return on our investment in terms of time and talent. And that's a record we hope to maintain." □

Recruitment Sources

California State University, Chico, Calif.
California State University, San Jose, Calif.
Florida International University, Miami, Fla.
Metro State College, Denver, Colo.
New Mexico State, Las Cruces, N. Mex.
Pan American University, Edinburg, Tex.
Southampton College, New York, N.Y.
Southern University A & M, New Orleans, La.
Sterling Community College, Sterling, Colo.
Tennessee Technical University, Cookeville, Tenn.
University of Colorado, Denver, Colo.
University of New Mexico, Albuquerque, N. Mex.
University of Oklahoma, Norman, Okla.
University of the Pacific, Stockton, Calif.
University of Tennessee, Knoxville, Tenn.
University of Texas, El Paso, Tex.
University of Washington, Seattle, Wash.
University of Wisconsin, La Crosse, Wis.
Xavier University, New Orleans, La.

Bill Barrett of the University of New Mexico prepares a backup of sources used for computer programs.

Pam Porter of the University of Wisconsin runs experiment measuring ion-molecule reaction constants, simulating upper atmosphere conditions.



When a Star Explodes

By LOUISE PURRETT-CARROLL

THE CHRONICLE of life on earth, etched in fossils, shows the comings and goings of many species. New ones evolve, others fade away. The changes are usually so gradual, spanning thousands of generations, that they might be imperceptible.

But the fossil archives also record mystifying sudden extinctions, when an entire species disappeared in a geologically very brief time. The best known is the demise of the dinosaurs. But there have been many others; the disappearance of the dinosaurs is only a chapter in an even more dramatic story: periodic mass extinctions involving a significant portion of all living species.

The dinosaurs died out at the end of the Cretaceous period, about 65 million years ago and were accompanied in their exodus by many other species of land and sea creatures that had successfully survived for 100 million years or more. Even more pervasive mass extinctions took place earlier in time, at intervals of roughly 100 million years.

This mystery has inspired one of the great paleontologic detective stories. But here, the question is not only whodunit, but how? There is even some question about whether a murder was committed at all, or if it's a case of death from natural causes.

Paleontologists have advanced many theories to explain the biological catastrophes: climatic changes, ecological competition from newly evolving species, changes in sea level, disease epidemics, poisoning by volcanic gases, increased radiation from the Sun or nearby stellar explosions.

Nor are paleontologists the only ones working on the case. Researchers in NOAA's Aeronomy Laboratory (one of the Environmental Research Laboratories) have applied their upper-atmosphere expertise to the search for an explanation.

There are some suggestive coincidences. Scientists have noted, for example, that extinctions of tiny marine animals have tended to occur when the Earth's magnetic field was passing through one its occasional polarity reversals. The lines of force of the magnetic field shield Earth's lower latitudes from bombardment by galactic cosmic rays, a flood of energetic particles that seems to wash through the entire galaxy. As the field is reversing polarity, however, it temporarily relaxes its guard over Earth. A Canadian geophysicist, Dr. Robert Uffen, has speculated that during these vulnerable periods galactic cosmic rays might shower down on the entire planet, and that this increased radiation might cause mutations among creatures on Earth.

The weakness in this theory was that the increased radiation from galactic cosmic rays alone would be insufficient to account for the observed changes.

NOAA's Dr. George Reid, Dr. Ivar S.A. Isaksen of the University of Oslo, and Drs. T.E. Holzer and Paul Crutzen of the National Center for Atmospheric Research pointed out another source of energetic particles that could augment the effects of the cosmic rays: the Sun.

During an intense solar flare, the Sun spews out energetic protons. Normally the Earth's magnetic field guides these solar protons to higher latitudes, limiting their impact. During polarity reversals, the field is weakened or may even disappear for periods of a few thousand years, the researchers argue, "allowing both solar protons and galactic cosmic rays access to much larger areas of the Earth."

These cosmic rays and solar protons could affect life on earth, but not in the direct way that Uffen envisioned, say the scientists. They proposed instead that this increased radiation would alter the composition of the atmosphere, admitting more ultraviolet, and that it is the ultraviolet that would do the damage.

Ozone in the stratosphere normally filters out much of the ultraviolet radiation from the Sun, making Earth more hospitable to life. Crutzen had found that solar protons and cosmic rays break up molecules in the stratosphere, leading to formation of nitric oxide, a well-known ozone destroyer. If a solar proton event occurred while the magnetic field is reversing, there would be "much more severe effects on the ozone shield than are presently possible."

Using a version of a model of atmospheric chemistry that Crutzen developed, the researchers calculated the ozone reduction that would result from cosmic rays and solar protons if a major solar flare occurred during a polarity reversal. They used proton emissions during an intense flare that occurred in August 1972, as a standard.

They found that "very substantial ozone reductions must accompany intense solar proton events during polarity reversals, and also that the maximum effect is reached 1 to 2 years after the event, while time required for the atmosphere to recover its initial condition is almost 10 years."

The calculations showed that during a polarity reversal, a solar proton event of the same magnitude as that of August 1972 would increase the effective ultraviolet dose at the ground by 15 percent. An event 10 times more intense would increase the dose by 55 percent, and one 100 times greater would cut the amount of ozone in the atmosphere in half and would more than double the biologically effective ultraviolet dose received at the equator.

"Such increases would inevitably have some effect on simple aquatic microorganisms, many of which presently seem to be living close to their maximum tolerance of ultraviolet radiation," the four noted.

They added that even if no solar proton event occurred during the vulnerable period, the ozone content of the atmosphere would still be reduced by 4.3 percent just by the continuing action of galactic cosmic rays.

There is an additional effect: The nitric oxide added to the atmosphere would combine with ozone to produce nitrogen dioxide. Nitrogen dioxide would absorb some visible light, reducing the amount of certain wavelengths reaching the surface of the Earth. For a solar flare 100 times as potent as the August 1972 event, the decrease would be 3.5 to 7 percent, depending on latitude. The effects would be partially offset by increased ultraviolet from ozone depletion, but there still could be significant changes in Earth's radiation budget and in lower-atmosphere circulation.

Then, says Reid, he and the other scientists began to wonder whether, if solar flares could account for the minor extinctions coinciding with magnetic polarity reversals, they also could explain the more catastrophic and massive extinctions.

But they weren't quite satisfied with the solar flare explanation, Reid recalls. "As with all suggested mechanisms, there remains a

Solar prominence 570,000 miles high, photographed by the Mt. Wilson and Palomar Observatories.

large element of speculation that is difficult to remove." The August 1972 solar flare is the most potent on record. However, accurate records of the radiation from solar flares span only a couple of decades. Basic knowledge about what causes flares and why some emit energetic protons and others do not is insufficient to say whether an event producing energetic particle downpours 100 times that of August 1972 could ever happen, "even once in a hundred million years. Or whether there is some absolute limit beyond which a flare cannot go."

Even if such a super-flare were possible, the nitrogen oxides it produced would stay in the atmosphere only a few years, he continues. So its effects would be too short-lived to set off major adjustments in climate or life forms.

Reid, Crutzen, and another NOAA Aeronomy Laboratory scientist, Dr. John McAfee, began to cast about for other explanations.

Solar flares are just one source of potentially destructive radiation. Scattered throughout the universe are the cloudy remnants of explosions that dwarf the mightiest solar flare. From time to time, for reasons unknown, an entire star explodes in a supernova, suddenly blazing to millions of times its normal brilliance, then shrinking to a smaller, denser version of itself.

The brilliant, varicolored Crab Nebula is generally believed to be the remnant of a supernova that the Chinese saw and recorded in 1054 AD. It, and other supernova remnants, or shells, says Reid, are now thought by many scientists to be the sources of galactic cosmic rays.

Astronomers have taken a radio telescope census of the supernova remnants in our galaxy that are visible from the southern hemisphere. They found about 100 of them, averaging 30 to 40 parsecs in diameter. (A parsec is an astronomical distance equivalent to about 19.2 trillion miles, or 31 trillion kilometers). Reid estimated that the "danger" range was within 18 parsecs (346 trillion miles, 553 trillion kilometers) of the remnant's center. He then figured the fraction of the galaxy occupied by supernova remnants and added in the frequency of occurrence of supernovas—a supernova occurs within our galaxy about once every 50 to 100 years. "You can plot it out, and get a waiting period for supernovas a given distance from you. For 20 parsecs [384 trillion miles, 614 trillion kilometers] it is 200 million years." Also affecting the odds are the facts that supernovas occur more often in the spiral arms of the galaxy, and that everything, including our sun, passes through the arms about once every 100 million years.

Another scientist went so far as to suggest that a supernova explosion in Earth's neighborhood could have been associated with climate changes that caused animal extinctions, but went no further in suggesting how these changes might have occurred. Reid, McAfee, and Crutzen picked up where he left off.

If a supernova explosion occurred ten parsecs from earth, the three reasoned, the solar system would probably remain within the supernova remnant shell for several hundred years before the shell faded or the galactic paths of the two entities separated them. Radio emissions from known supernova remnants suggest that a planet within the remnant cloud might be subjected to 100 to 1,000 times the "normal" levels of cosmic rays.

Photo: NASA.

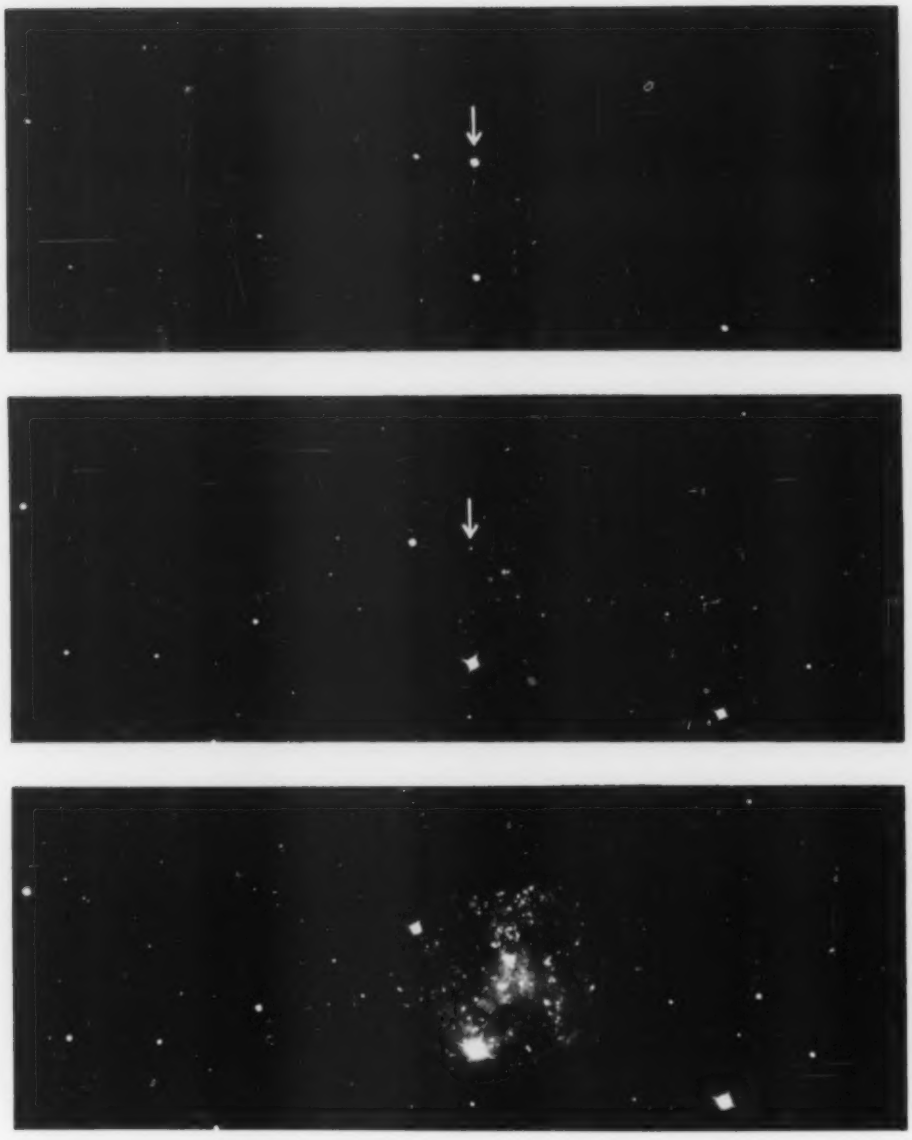
The famous Crab Nebula, remnant of an 11th Century supernova and still visible by telescope in the skies today, as recorded by the U.S. Naval Observatory.

Again, the researchers used Crutzen's model to evaluate the effects of such conditions on the solar radiation penetrating earth's stratosphere. They looked at two hypothetical cases. In one, the cosmic ray influx was 100 times present-day; in the other, it was increased by 1,000. They found that the first case would result in ozone depletion of 64 percent, with 89 percent for the second case. Nitrogen dioxide would increase by factors of 13 and 130, respectively.

These changes in the composition of the atmosphere would produce a secondary effect: altering the character of sunlight reaching Earth's surface. The decreased ozone would admit more ultraviolet, while the additional nitrogen dioxide would block out some of the blue and green light in the visible part of the spectrum.

If the cosmic ray dose were increased by only 100 times, this would mean a slight increase in the total amount of radiation warming the Earth's surface because the amount of blue and green blocked out is less than the increase in ultraviolet. But the situation reverses for the thousandfold increase. Then, the amount of nitrogen dioxide becomes great enough for its absorbing effects to overwhelm the effects of the decrease in ozone, and the total amount of solar radiation decreases by several percent. This would mean a drop in global average surface temperature that was estimated to be about 5.4 degrees Fahrenheit (3 degrees Celsius).

However, the researchers emphasize that the climate is such a complex machine that this figure represents mainly a "qualitative indi-



Supernova (3 photos at left above) as recorded by the Mt. Wilson and Palomar Observatories in (top to bottom) 1937, 1938, and 1942. The great galaxy in the constellation Coma Berenices (above) was photographed by the same astronomical facility in 1940 (with supernova) and in 1941 (without supernova).

cator of major climatic perturbation.''

This would set off a number of climatic repercussions. The amount of water vapor the atmosphere can hold depends in part on temperature. A 3-degree-Celsius drop in surface temperature, for example, would mean a 20 percent drop in the amount of water vapor in the atmosphere. ''This would decrease the greenhouse effect, tending to decrease surface temperatures even more and would also lead to changes in cloud properties, with further climatic consequences,'' predict the NOAA and NCAR scientists. There would be widespread drought. But there would not be a true ''ice age,'' the scientists believe, because above-normal precipitation is probably required to build the massive sheets of ice that burden the continents during ice ages.

The reduction in visible radiation that would be caused by a thousandfold increase in cosmic radiation would also affect photosynthesis on a global scale, the scientists continue. Blue and red light are most conducive to photosynthesis, they point out, and blue would be cut down by 30 percent. Over the course of a year, the equator would receive about as much of the important wavelengths of blue light as temperate zones do now.

''Coupled with the probable drought conditions resulting from the decrease in global temperature, a severe decrease in the abundance of plant life is probable,'' they conclude.

All the extra nitrogen oxides in the atmosphere, the scientists add, would eventually find their way to the Earth's surface as fixed nitrogen. For the hundredfold cosmic ray increase, that would mean an additional 22 megatons (20 billion kilograms) of the nutrient falling on the Earth and seas each year. For the thousandfold increase, the amount would be 220 megatons (200 billion kilograms). This is equivalent to the total amount now fixed in a year by biological processes. This ''vast influx of cosmic fertilizer,'' says Reid, would have an impact on terrestrial life ''that is not easily estimated.''

Reid, Crutzen, and MacAfee conclude that ''passage of the Earth through a supernova remnant would be likely to cause a prolonged period of harsh environmental conditions'' on Earth—burning ultraviolet radiation, drought, cooler temperatures, and suppressed photosynthesis.

Whether all this could account for the major extinctions of animals is a matter of speculation, they concede. And whether Earth actually did pass through a supernova remnant is unknown and, perhaps, unknowable. But given the number of supernova explosions in our galaxy and the enormous span of time, the odds are in favor of it. ''A nearby supernova explosion is not a dim and exotic possibility when viewed in the geological time scale but rather an event that may well have occurred several times'' within the billion-year history of life on Earth. □

NOAA Profile

The Plank Owner

By JOHN STRINGER

Earl Rayfield (right) congratulates Lt. Thomas M. McGlynn, Harbormaster, for his assistance after the successful visit of the NOAA Ship Researcher to Washington, D.C. last year.

President Jimmy Carter issued a proclamation on April 18 that called upon "public officials, users of the oceans and coasts, environmental organizations, industry, the media and civic leaders to join together to make the public aware of the importance of our ocean resources. . ."

A week before that, the NOAA ship Researcher had departed Miami, Fla., her destination Washington, D.C. Her visit to the Nation's Capital would be handled by the National Ocean Survey's Office of Fleet Operations—and specifically, by Earl Rayfield, Chief of the Operational Support Branch. The Researcher was bound for Washington on exactly the kind of mission that the President's proclamation envisaged.

Seven months before the Researcher left her home port in Miami, Rayfield was at work on his job to provide the public the opportunity to visit the ship. His efforts were noted in a short item in the NOS Director's weekly report to the NOAA Administrator. "Preliminary work toward the NOAA Ship Researcher's upcoming Washington visit (April 1978) was started by checking controlling depths on the Potomac River, contacting D.C. Harbor Police regarding dockage availability, and contacting the Virginia Pilots Association."

Rayfield's familiarity with problems posed by ceremonial and public visits of NOAA's ships is well known throughout NOAA. "A seemingly endless list of details are involved with such as event," he said.

Probably nobody in NOAA has a job description that includes such duties as he is occasionally assigned, Rayfield supposes. He is well aware that to display successfully one of NOAA's research platforms requires the efforts of a great many people for a relatively long period of time—14 to 16 hours a day. "I have a lot of help, from at least 150 people," he said. But it is his responsibility to get the job done, a responsibility that has increased every time a NOAA ship participates in a visit to the Nation's Capital.

In June 1977 the NOAA ship Researcher provided a one-day demonstration cruise for 100 United Nations Law of the Sea delegates at the request of the Hon. Elliott Richardson. "The purpose of the cruise," said Rayfield—who served as coordinator for the shipboard activities—"was to convey the most modern techniques of monitoring the effects of ocean dumping to the nations of the world."

Rayfield said the most difficult part of the project was the coordination of the shoreside portion of the program in which members of the Office of Fleet Operations—Wheatly Ward, Galen Reynolds, and Scot McKellar—worked with Richardson in New York 10 days prior to the scheduled cruise.

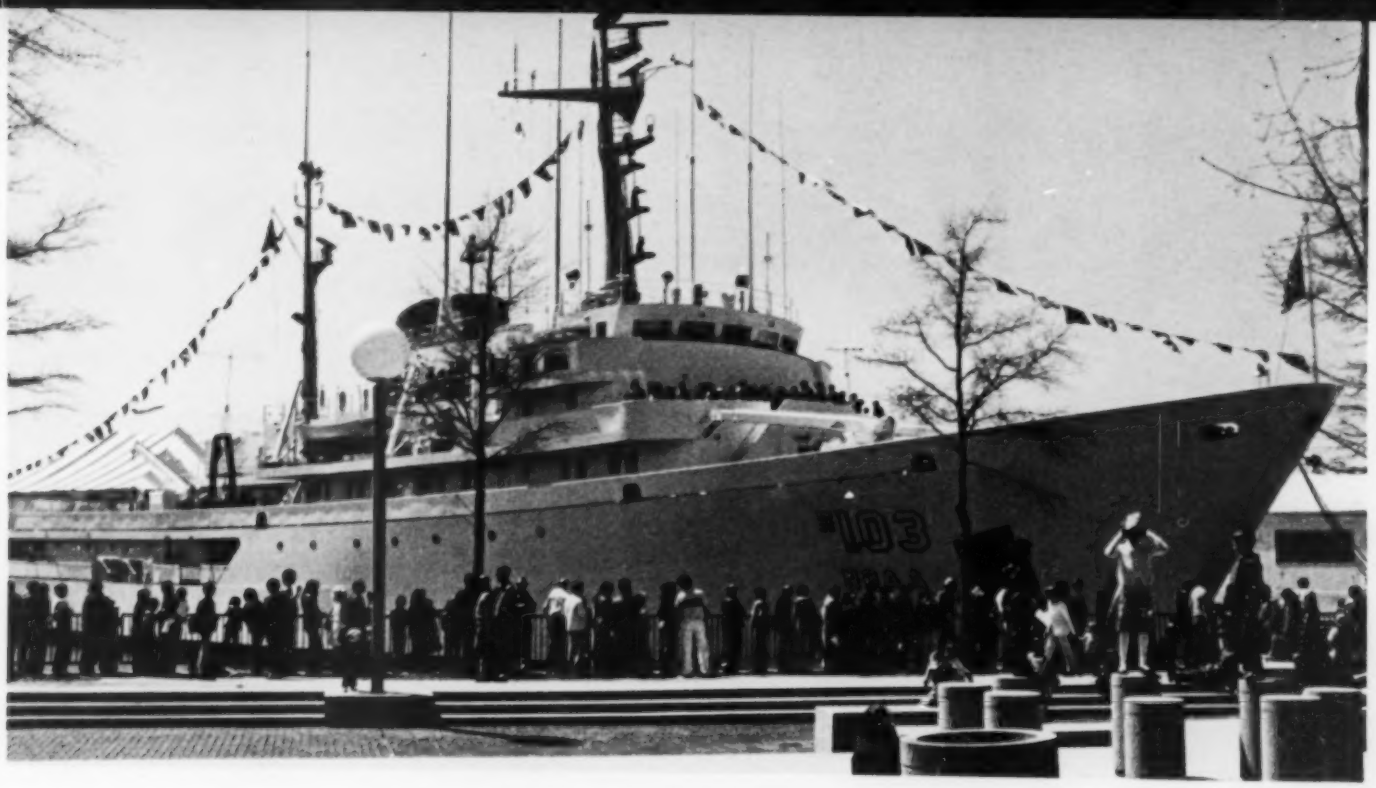
"Going to sea for one day on a ship 273 feet in length with 100 dignitaries on board may seem routine, but since NOAA ships are not designed for such accommodations, the logistical problems are interesting and sometimes humorous. Additional life jackets must be brought aboard as well as additional Dramamine. The ship is big, and the layout can be confusing to a landlubber. One delegate got lost on every return from the "head." Diplomacy, he said, was required by the ship's officers in explaining to many of the delegates why NOAA ships sailed without beer and wine.

Rayfield was born at the height of the Depression in the small village of Crisfield on Maryland's Eastern Shore. "There wasn't enough livelihood to support the whole family on the farm we had," he recalled. "So my father turned the farm over to his brother, and we came up to Washington where he got a job shucking oysters."

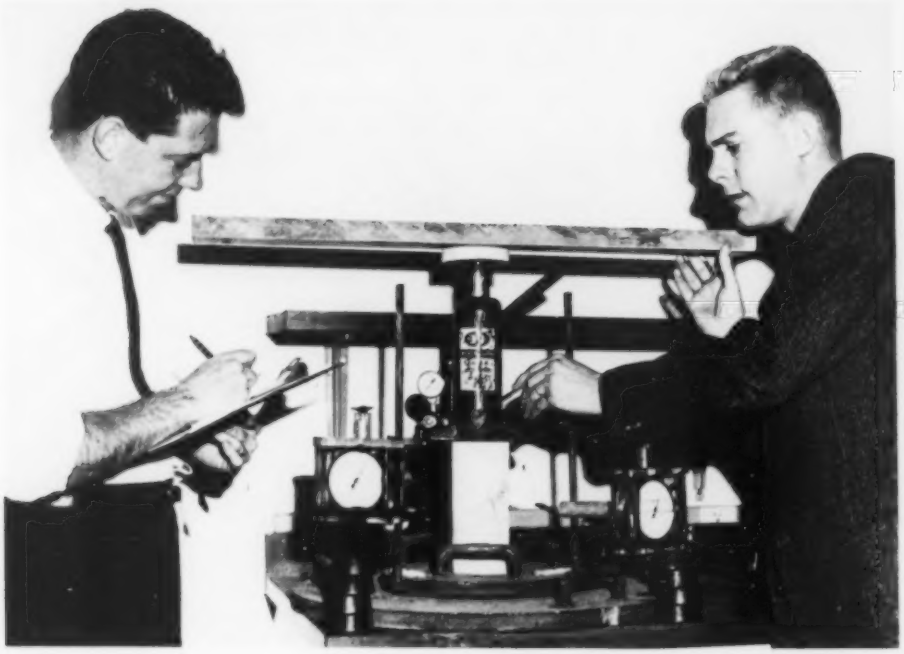
During the years Rayfield grew up in Washington, he always returned to the Eastern Shore when school was closed for summer vacation. There he stayed with relatives on Smith Island located near the Maryland/Virginia boundary in the middle of the Chesapeake Bay. "In the old days, about 25 to 35 years ago," said Rayfield, "there used to be a fair amount of commercial fishing down there, but today it's mostly crabs in the summer and oysters in the winter."

As a youngster Rayfield crabbed like everybody else on the island. He made his own trot line—a long piece of cord with pieces of eel tied to it for bait. "It's a good job for a teenage boy," he said. "It develops independence, preparedness, and alertness at a good age. When you're several miles from home alone on the water, you are forced to make all the decisions related to your well-being. Preparedness and imagination are forced on the crabber, too, because if the engine quits, the crabber faces a long lonesome trip home. And alertness is critical—if you're not alert, you won't make any money.

"The trot line lies on the bottom," Rayfield continued, "and you take a small boat about 16 feet, and go slowly up and down the line, pulling it out of the water. As the line comes out of the water, the crabs have the tendency to follow the bait up near the surface where



Thousands wait to board the NOAA Ship Researcher (top) during National Oceans Week held last April in Washington, D.C. Officials from the National Ocean Survey (above) escort the Researcher to Maine Ave. aboard the D.C. Harbor Police cruiser. Earl Rayfield (above right) waits for the Researcher's gang plank to be lowered. From left to right: Rayfield, R. Adm. Allen L. Powell, Scott M. McKellar, Capt. James F. Midgley, and R. Adm. Herbert R. Lippold, Jr. The Hon. Elliott Richardson (right) signs the Researcher's guest log while Cdr. Walter F. Forster II looks on.



Rayfield (upper left) takes daily measurements during the Beach Erosion Deposition Study on the North Carolina coast in 1965. Several years later, Rayfield and Dr. P. W. Harrison (upper right) discuss modifications in the Land and Sea Interaction Laboratory's plate-load apparatus used in studying the response of continental shelf sands to natural and artificial loads.

you can see them and net them."

At the end of the day, the crabs were sold. "I can remember the highest price we ever got for crabs when I was a kid, five cents a piece."

He said that in those days almost every boy from that part of Chesapeake Bay trotlined. "You don't have to be an adult, and you don't need a lot of machinery—a one cylinder motor is all we ever used. It's a job that a youngster can do."

Upon graduation from high school in 1951 Rayfield enlisted in the Air Force and was assigned to a mobile weather unit which traveled throughout Europe in support of NATO forces. His resourcefulness was soon recognized by members of the Fourth Allied Tactical Armed Forces.

While on maneuvers with NATO forces, the troops were not permitted to leave the compound or the maneuver area for long periods of time. "The weathermen," said Rayfield, "had a unique opportunity—we needed hydrogen to fill our balloons, and hydrogen was not stored in any quantity on the maneuver site. So we were given a special pass, and were among the very few who were able to come and go from the compound. When the other fellows heard that these little trips were going on, we became the wine deliverers. For every 2,500-pound cylinder of hydrogen, we would bring back 250 gallons of wine."

Rayfield's experience in the Air Force was more than adequate for him to qualify for a position with the U.S. Weather Bureau when he was discharged. Working days, he went to night school at the U.S. Department of Agriculture Graduate School where he studied meteorology. But his goal—to become a certified meteorologist—took a 180° turn when he accepted a job with the Office of Research and Development, U.S. Coast and Geodetic Survey.

"From the career point of view," said Rayfield, "the switch from the gaseous world of meteorology to the wet world of oceanography was the best move that I made."

He moved to Norfolk, Va., where the Office of Research and Development was engaged in a beach erosion survey that required someone with a background in weather observing. "The idea was that the meteorological forces act on the ocean, which in turn acts on the beach," said Rayfield, who was to spend his next four years in Norfolk developing models for the study of beach erosion. During the winter months, however, Rayfield was sent to the Bahamas.

"We chose the Bahamas," he said, "because we found that clear water and warm temperatures were conducive to the development of monitoring systems that would be applicable to on-going studies in Florida, the Carolinas, Virginia, Maryland, Delaware, and even Massachusetts."

Since diving operations were a major part of the studies, a great deal of gear had to be carried during the surveys which lasted upwards to 40 days. "We generally worked about 15 to 20 days in a row without a day off."

While assigned to the Bahama project, Rayfield worked for a laboratory director who happened across a theory that the missing continent of Atlantis was most probably located off the east coast of Florida. The laboratory director, a geologist, became interested in this theory and analyzed the magnetic field on the Bahamas Bank and studied rock formations and sea floor elevation changes.

"As a part time job," said Rayfield, "I assisted him in the search for Atlantis, a search predicated on his studies and on the find of a black organic rock about the size of a watermelon." The origin of the rock was never explained, but it was analyzed by three laboratories which agreed that the rock was not native to the Bahamas.

"On our days off, we did geological drilling and took core samples dating back 50 million years," said Rayfield, who calls this the most unusual thing he has ever done. "We punched holes all around the Bimini Islands, including some nearby keys, in search of similar materials that were not native to the surface. We even punched holes from offshore rigs to find some clue as to the existence of Atlantis." They were never successful.

Confined to a Virginia Beach hospital bed in 1968 with a painful back problem, Rayfield found that the days passed slowly until one morning he received a telephone call from C&GS headquarters, Rockville, Md., offering him the job as Chief, Marine Information Branch. The caller said she would do the paper work, and then asked how long he would be at this number. "About 30 days," said Rayfield. "I'm in traction."

The caller, who offered to help Rayfield, worked for the chief of the Operations and Requirements division. Her name—Deanna, nicknamed Dee—became Mrs. Rayfield three years after the telephone call.

After Rayfield returned to headquarters, he was assigned to the newly formed Office of Fleet Operations. "There are very few 'plank owners' in Fleet Operations," said Rayfield, who describes a plank owner as a person who is intimately involved with the construction of a new ship or the formation of a ship-oriented office.

"Some of the people involved during the organization of the new office," he said,

Dee Rayfield inspects (top) one of several hammocks made by Earl.

Earl keeps his goose decoys (above) ready for his yearly hunting trips to Maryland's Eastern Shore. An antique copper still (said to be inoperable) is the focal point in the Rayfield study.

Dee, who is recognized for her gourmet specialties featuring an Italian influence, checks her hot peppers (upper right) hanging in her kitchen.

"were Admiral Eugene Taylor and Admiral Powell, who was the first associate director. They're plank owners." Rayfield's duties as chief of the Operational Support Branch were to provide operational support to the fleet, such as coordinating program users' requirements with the ship's capability to assure that the necessary equipment would be available for data monitoring activities.

Rayfield would soon become the chief firefighter for Fleet Operations when he successfully completed an emergency run to Massachusetts in 1971 to pick up the new Tidal Current Meter System (TICUS) for NOAA's Atlantic Marine Center in Norfolk, Va.

"It was the most unusual firefighting episode," as Rayfield refers to his assignment between Christmas and New Year's Eve 1971. "The agency was advised they would have to take delivery of the $250,000 TICUS before the end of the calendar year," he said. "The Director was looking for someone who was not on leave, had signatory responsibility, understood the TICUS, and could drive a tractor truck. Let's say I was available."

Rayfield drove to Waltham, Mass., in an ice storm, accepted the system on the 30th of December, and delivered it to the Atlantic Marine Center on New Year's Day where the engineers began calibrating the instrument.

Rayfield and Dee were married in 1971. Both have an interest in artifacts, which are scattered throughout their house in Damascus, Md. Among their most prized possessions are a hand-carved totem pole by retired NOAA Corps officer Capt. R. E. Williams, a copper still from Dillon, S.C. (Said Rayfield: "I brought it together with a recipe to make corn liquor, and I look forward someday to trying it out!"), and a beautiful antique bench that Dee refinished with "a lot of hard work and perseverance."

They both enjoy country auctions, and while attending one early last fall, they came across their greatest find: a historic house near Union Bridge in Carroll County, Md.

"It's pre-Civil War, about 1840," said Rayfield. The original brick structure has three fireplaces and random width flooring. "The house has a bit of Civil War history according to the family descendants, in that the Confederate soldiers on their way to Gettysburg were starving. They seized the garden and bolted down the food while the home's occupants watched behind locked doors."

The Rayfields have bought the house at Union Bridge. Some work will have to be done, but the few changes necessary are more decorative than structural. When the work is completed, there will be plenty of room for Earl's three children—Dianne, who is Mrs. Gordon Walker of Virginia Beach, Va.; Karen, who is Mrs. Phillip Hungerford of Virginia Beach; and son Timothy, a student in Brownwood, Tex.

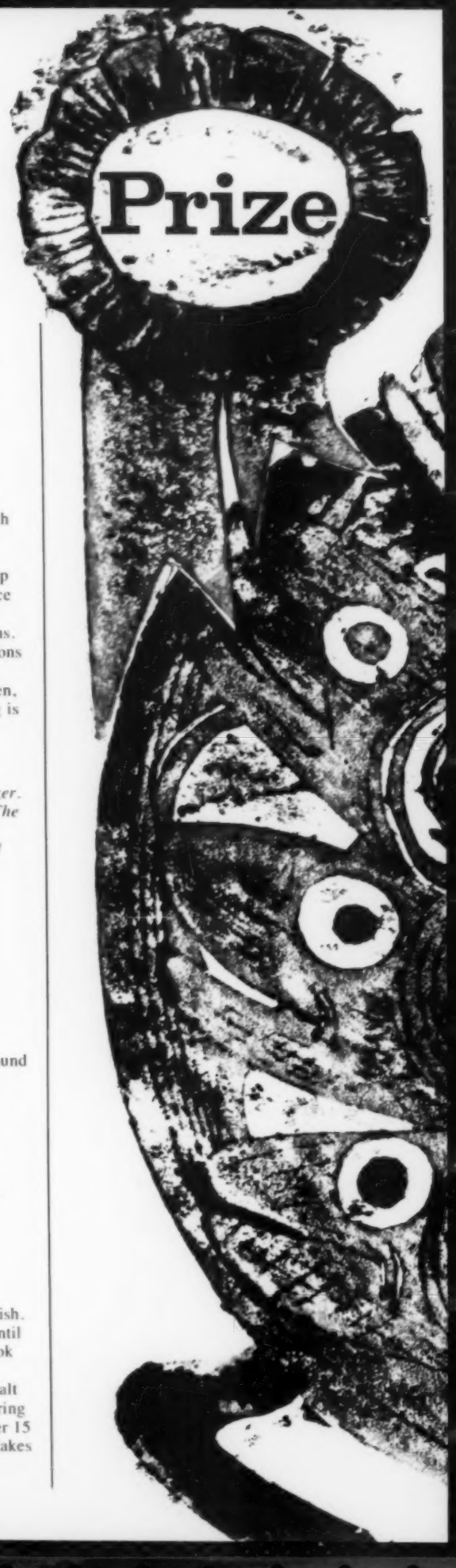
Reflecting on last year's successful visit of the Researcher, Rayfield said, "It's a continuing activity, and I'm part of it from time to time. "I've been told that each event has been a success in letters of commendation from the people at the administrator's level. That makes me feel very good."

Shortly after the Researcher's visit to Washington, D.C., Rayfield received a letter from NOAA Administrator Richard A. Frank who wrote: "I understand you were involved in almost everything from arranging for all facilities required by the ship such as pilots, tugs, electrical power, trash disposal, guard service, etc., the tent, the catering items, flowers, tour guides, and liaison with Fisheries for food. I don't quite know how you did it all; I assume simply a matter of personal competence and good management skills. NOAA owes you a debt of gratitude, and I owe you my personal appreciation."

Rayfield also has had letters of appreciation from Francis W. Richelderfer, Robert M. White, and Adm. Allen L. Powell. "In all, the most rewarding times are working on special projects—such as visits by the Researcher," he said, "which involve all components of NOAA toward a common goal."

The goal is public understanding of the programs and activities of NOAA. Said the Washington Star's Donald Hirzel: "Aboard the Researcher, visitors will find a $750,000 computer and equipment used in the research of ocean currents, the structure of the ocean floor and animal life at great depths. On display will be pictures of sea life taken near the bottom of the Continental Shelf. . ." □

Palate-Pleasing Prize



Confidence in cooking comes from having a recipe that has been proven successful both with the cook and with those who taste it.

The Catfish Farmers of America and the American Catfish Marketing Association approved of Rose McCorkle's* Stuffed Farm-Raised Catfish Almondine. *It won first place in the 1978 National Farm-Raised Catfish Cooking Contest.

Richie's Special Fish Chowder ***and* Ella's Clam Oreganata** ***won a following for Richard and Ella Orsini in St. Augustine, Fla., when they had their restaurant.***

Off Shore Bake ***has the support of the women of Gloucester, Mass., who included it in their cookbook, "The Taste of Gloucester."***

Joanne Sasek's* Sole Fillets Thermidor** ***won recognition at the 1978 National Fisheries Institute convention in Chicago.

With these recipes, who can lose?

Stuffed Farm-Raised Catfish Almandine

- 8 small pan-dressed farm-raised catfish, fresh or frozen
- 10 medium cooked shrimp, chopped
- 1 can (6 ounce) crabmeat, well drained
- ½ cup white wine
- 1 tablespoon chopped onion
- ½ teaspoon salt
- ⅛ teaspoon pepper
- ⅓ cup margarine or butter
- 1 package (4 ounces) sliced almonds
- 1 tablespoon lemon juice
- Cherry tomatoes, parsley sprigs, lemon slices (garnish)

Thaw catfish if frozen. Clean thoroughly and dry with absorbent paper. Combine shrimp, crabmeat, wine, onion, and pepper and marinate for 30 minutes. Drain and reserve liquid. If the cavity of the fish is small, enlarge cavity by cutting a small pocket along the backbone. Stuff each fish with the shrimp and crabmeat mixture. Sprinkle fish with salt. Fry fish in margarine until brown on both sides and fish is done and flakes easily when tested with a fork. Remove fish from pan to a warm platter. Add almonds, lemon juice and reserved marinade to fry pan; cook until almonds are brown. Spread over catfish. Garnish with tomatoes, parsley and lemon slices. makes 4 servings.

Ella's Clam Oreganata

- 4 dozen fresh, small clams
- 1 can (8 ounces) Italian seasoned bread crumbs
- ⅔ cup olive oil
- ¼ cup chopped parsley
- 1 tablespoon oregano
- 5 cloves garlic, crushed
- Lemon slices (garnish)

Shuck clams. Reserve 30 of the clam shell halves, clean and sterilize. Rinse clams with cold water to remove any remaining shell particles. Drain and mince clams. In large mixing bowl, combine bread crumbs, ½ cup olive oil, parsley, oregano, and garlic. Place clam shells on cookie sheets and fill with approximately 1 tablespoon of minced clams. Top each clam with approximately 2 teaspoons bread crumb mixture.* Drizzle remaining olive oil evenly over clams. Bake in hot oven, 450° F., for 5 to 8 minutes or until topping is golden brown. Garnish with lemon slices. Makes 30 hors d'oeuvres.

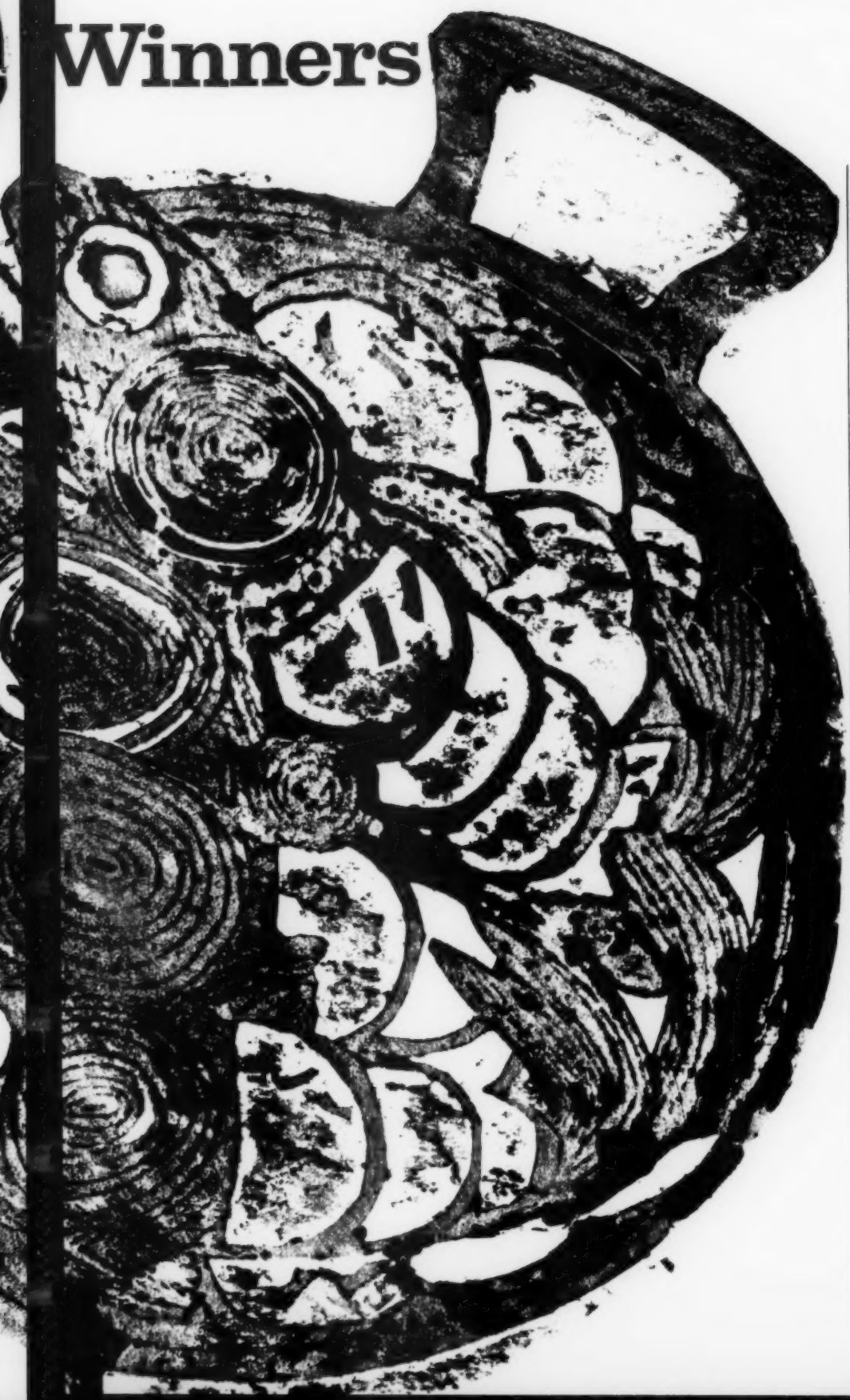
**If desired, clams may be frozen. Place filled clam shells on a cookie sheet in freezer. When solidly frozen place in plastic bags. The clams may be kept in freezer for several months. After thawing, drizzle with oil and follow cooking instructions.*

Richie's Special Fish Chowder

- 2 pounds fish fillets, fresh or frozen
- ¼ pound salt pork or bacon, coarsely ground
- 1 tablespoon cooking oil
- 3 medium onions, peeled and coarsely ground
- 1 teaspoon thyme
- 4 medium potatoes, peeled and ground
- 2 cups canned tomatoes, ground
- 1 cup carrot chunks, peeled and ground
- 1 cut celery chunks, ground
- 1 to 2 cups boiling water
- 1 teaspoon salt
- ¼ teaspoon black pepper
- 1 teaspoon oregano

Thaw fillets if frozen. Skin fillets; grind fish. In an 8-quart soup pot, cook pork in oil until golden brown. Add onions and thyme, cook until onions are tender. Add potatoes, tomatoes, carrots, celery, boiling water, salt and pepper. Simmer 15 to 20 minutes, stirring frequently. Add fish to oregano and simmer 15 minutes, stirring frequently. Serve hot. Makes 6 to 8 servings.

Winners



Off Shore Bake

2 pounds fish fillets (2 pieces) cod, pollock, cusk or haddock
¼ cup bread crumbs
2 tablespoons grated Italian cheese (Romano or Parmesan)
1 egg hard boiled (sliced)
1 teaspoon oregano
1 cup mashed tomatoes or tomato sauce
1 medium onion (sliced)
2 large potatoes (1 lb.) medium sliced salt and pepper to taste
¼ cup olive oil

Oil a 14 × 10 baking tray. Place 1 piece of fish in center, sprinkling with salt. Sprinkle bread crumbs on fish. Sprinkle 1 tablespoon of grated cheese evenly over the fish. Place the sliced egg and about 3 tablespoons of the tomatoes on the fish, and add oregano. Pour a little oil all over the stuffing and sprinkle with 1 tablespoon of cheese. Place the second fillet on top. Place cut-up potatoes and onion, mixed together with a little salt and pepper, around the fish. Add the tomatoes over the fish, onions and potatoes, and add the remaining oil. Cover with foil. Bake 375° F., for 45 minutes until potatoes and onions are cooked. Serves 6.

Joanne Sasek's Sole Fillets Thermidor

3 pounds sole fillets or other thin fillets, fresh or frozen
1 (8 ounce) salmon fillet
⅛ teaspoon pepper
1½ teaspoon salt
2½ cups milk
½ cup margarine
½ cup flour
½ pound (2 cups) mild cheddar cheese, grated
½ cup lemon juice
Paprika

Thaw sole and salmon fillets if frozen. Cut sole fillets into 8 portions and salmon fillet into 8 equal pieces. Place a piece of salmon on each sole portion; sprinkle fish with pepper and 1 teaspoon salt; roll. Place fish rolls in a baking dish 12 × 8 × 2 inches. Pour milk over rolls and bake in a moderate oven, 350° F., for 30 minutes or until fish flakes easily when tested with a fork. Transfer fish rolls to deep ovenproof serving platter and keep warm. Reserve milk. In saucepan melt margarine, stir in flour and remaining ½ teaspoon salt. Add milk gradually and cook until thick and smooth, stirring constantly. Stir in cheese until melted; add lemon juice. Pour sauce over baked fish rolls. Sprinkle with paprika. Broil about 4 inches from source of heat for several minutes until lightly browned. Makes 8 servings.

noaa/update

Interagency Committee Formed

Ocean Accord Signed

NOAA and the Environmental Protection Agency have agreed to coordinate research and regulatory activities on the use and protection of oceanic and coastal waters.

Formation of the NOAA-EPA Interagency Committee for Program Coordination was announced by NOAA Administrator Richard A. Frank and EPA Administrator Douglas M. Costle at a ceremony marking the signing of the Committee's charter.

NOAA Administrator Richard A. Frank and EPA Administrator Douglas M. Costle sign an interagency agreement regarding oceans and coastal waters.

Frank pointed out that NOAA has growing responsibilities in the management of U.S. coastal resources and the development of new industrial technologies that will exploit the wealth of the oceans. EPA is responsible for environmental protection of the Nation's coastal waters and the oceans, a responsibility, Costle said, "that expands and grows more complex in the light of new and changing offshore activities and technologies."

The Administrators said the Committee would be concerned with a variety of problem areas in which both EPA and NOAA have responsibilities, such as deep seabed mining and the protection of marine sanctuaries and coastal waters from degradation caused by wastes discharged from land-based sources. Among its first priority actions will be a search for ways the two agencies can cooperate in efforts to control algal blooms in coastal waters. These blooms thrive on the nutrients (mostly phosphorous and nitrogen) in runoff from land and in wastes discharged through ocean outfalls.

A study will be made by the Committee, Frank and Costle said, of the possible joint use of facilities of both agencies for research on ocean dumping, pollution, monitoring, and meteorology.

The agency heads also noted that the proposed Deep Seabed Hard Mineral Resources Act could give both NOAA and EPA major mandates in managing the recovery of minerals from the seafloor by privately financed ventures. It is essential that these operations be conducted with the least possible damage to the environment, they said.

TIROS-N Carries Most Advanced Data System

TIROS-N was successfully launched into near-polar orbit in mid-October.

The purpose of the new spacecraft, the first in a series of third-generation, operational, environment-monitoring satellites is to help NOAA's meteorologists, oceanographers, hydrologists, and other scientific environmental experts maintain and perhaps improve the quality of life on Earth through better monitoring and analysis of its environment.

This means such things as improved weather forecasts in the short and long range; providing better information for water resource management and flood forecasting; locating and analyzing ocean currents, areas of upwelling and their effects on fishing, shipping and other marine interests, and even providing more accurate information for warning of high energy solar radiation levels above the atmosphere.

For the first time ever, through an advanced data collection and platform location system, the TIROS-N series spacecraft are able not only to collect and transmit environmental data from platforms on land, at sea, and airborne, but also to determine the geographic location of those platforms which are in motion on the sea surface or aloft.

A similar spacecraft, NOAA-A, will be launched shortly to complete the two-satellite system. TIROS-N and all subsequent spacecraft will be operated by NOAA and, beginning with NOAA-A (to become NOAA-6 once in orbit), will be funded by NOAA. In addition to normal operational use, NOAA will rely on the TIROS-N and NOAA-A to support the Global Weather Experiment.

The onboard sensors and the ground equipment necessary to support TIROS-N are new, different, significant, and certainly advanced. Together they are designed to deliver an array of data to the ultimate users that could not be achieved by the two previous operational systems, TIROS (Television Infrared Observations Satellite) and ITOS (Improved TIROS Operational System).

Epstein Named Director Of New National Climate Program Office

A National Climate Program Office has been established with the Office of the NOAA Administrator and Dr. Edward S. Epstein named Director.

Establishment of the National Climate Program, and the office to administer it, results from adoption of the National Climate Program Act of 1978, recently signed by President Carter. The Secretary of Commerce directed that the program be established within NOAA.

The purpose of the National Climate Program is to assist the Nation and the world to understand and respond to natural and human-induced climate processes and their implications.

The program was enacted because weather and climate affect food production, energy use, land use, water resources, and other factors vital to national security and human welfare, and because the Federal Government had not given sufficient attention to assessing and applying information available.

"Climate fluctuation and change occur on a global basis, and deficiencies exist in the system for monitoring global climate changes. International cooperation for the purpose of sharing benefits and costs of a global effort to understand climate is essential," the Act states. The new Office will serve as the principal focus for coordinating U.S. participation in the World Climate Program that is currently under development.

Ocean Management Merges With Coastal Zone, Knecht Is Head

The Offices of Coastal Zone Management and Ocean Management have merged.

Robert Knecht, Assistant Administrator for Coastal Zone Management, is the Assistant Administrator for the new office, and Samuel Bleicher, Director of the Office of Ocean Management, is the Deputy Assistant Administrator.

Since the Office of Coastal Zone Management is a legislatively mandated name, the new office will still be called Office of Coastal Zone Management, although a revised name is expected when the Coastal Zone Management Act is reviewed by the Congress.

The merger was partly a result of the similarity of the activities of the two offices.

Some programs, like the marine sanctuary and estuarine sanctuary programs, were already working closely together. Also, the recent passage of the Outer Continental Shelf Lands Amendments, which give NOAA new responsibilities, led to the conclusion that the time was right to establish a closer relationship between the two programs.

DOC Awards Gold And Silver Medals

Twenty-two NOAA employees and two NOAA ship crews were awarded Department of Commerce gold and silver medals by Secretary of Commerce Juanita Kreps in ceremonies on October 23.

Gold medals, given for contributions of major significance to the Department, the Nation, or the world went to 11 employees. Silver medals, for contributions of unusual value, including unusual courage or competence in an emergency, were given to 11 employees and to the crews of the NOAA ships Heck and Rude.

Gold Medals

Leonard W. Snellman, Chief of the Scientific Services Division of the National Weather Service's Western Region Headquarters in Salt Lake City, Utah, for outstanding application of meteorological research to operational weather forecasting.

Clifion W. Green, Meteorologist in Charge of the National Weather Service Forecast Office in Jackson, Miss., and *Earl W. Estelle,* Chief of the Public Services Branch, NWS headquarters, for their work with NOAA Weather Radio.

Green's award is for initiating the concept of Federal-State cooperative agreements for rapid and cost-saving installations of NOAA Weather Radio transmitters throughout the United States. His pioneering effort in Mississippi, was a model for similar agreements subsequently negotiated by Estelle in more than 35 states.

Estelle's award is for his work in negotiating the fast-paced and cost-saving agreements with State governments, enlisting their aid in installing and maintaining the transmitters.

Dr. Donald Barrick, Michael Evans, and *Dr. Bob Weber* of the Environmental Research Laboratories' Wave Propagation Laboratory in Boulder, Colo., "to recognize the outstanding contributions of the three persons responsible for creating the unique Coastal Ocean Dynamics Application Radar (CODAR) oceanographic measurement system."

When positioned to overlook coastal waters, the portable radar system measures ocean currents out to distances of 70 kilometers (40 miles) from shore over an area up to 5,000 square kilometers (2,000 square miles) and produces a map depicting ocean currents in virtual real time.

Dr. Norton Strommen, Dr. Sharon LeDuc, and Dr. Clarence Sakamoto research scientists with NOAA's Environmental Data and Information Service in Columbia, Mo., for their unique contributions to National programs to alleviate the impact of climatic fluctuations on world food supplies.

The research team conceived, developed, and successfully tested crop yield/climate models that provided timely and accurate estimates of future wheat yields for the U.S. Great Plains and six foreign countries. These were developed to meet NOAA's commitment to resolve the problems of world hunger through mathematical crop/climate modeling for the Large Area Crop Inventory Experiment (LACIE)—a joint U.S. Department of Agriculture, NASA, and NOAA experiment.

Malcolm Reid and Dr. Augustine Y.M. Yao, meteorologists with NOAA's Environmental Data and Information Service, for outstanding leadership and competence in developing and implementing a real time, operational climate/crop assessment system to provide more timely and accurate crop production estimates for the major wheat growing regions of the world.

Silver Medals

Joe Haskell Allen, a geophysicist with NOAA's Environmental Data and Information Service for his outstanding leadership and accomplishment in promoting international multidisciplinary cooperation in the International Magnetospheric Study (MS) as head of its Central Information Exchange Office.

Harold G. Beard, a geodetic technician with the Field Operations Branch, Operations Division of the Office of National Geodetic Survey in Rockville, Md., for "his sustained high performance as a field coordinator for the Southern California Releveling Project (SCRP), a vital part of the Federal Earthquake Hazards Reduction Program.

Willette M. Carlton, a principal scientist with the National Meteorological Center, National Weather Service, for key contributions to the Center's primary weather support mission.

Robert R. Freeman, Deputy Director of NOAA's Environmental Science Information Center, for outstanding contributions in developing and implementing NOAA's Oceanic and Atmospheric Scientific Information System (OASIS), initiating the Regional Coastal Information Center program, and expanding the international Aquatic Sciences and Fisheries Abstracts.

Leon R. LaPorte, physical scientist in the Environmental Data and Information Service, for his invaluable and long-term contributions to National and international publication and exchange of scientific data and information resulting from large-scale, multinational, environmental research projects.

Elliott A. Macklow of the Office of Public Affairs, for his consistent production of award-winning films concerning NOAA activities.

Films producted by Macklow are seen by millions of persons each year. Theatrical versions have been made of several of his films for showing at Rockefeller Center and other major commercial theaters around the country.

Captain Ray E. Moses, Manager of the Marine Data Systems Project of the National Ocean Survey in Rockville, Md., for his "outstanding managerial capabilities and initiatives. His dynamic leadership and innovative management techniques and considerations have directly and materially contributed to the effectiveness of the project management organizational concept of the Marine Data Systems Project."

Frank T. Quinlan, Chief, Climatological Analysis Division of the National Climatological Center in Asheville, N.C., for his direction of the NCC effort in support of new National environmental projects of major importance, such as the development of solar energy and its application to practicable projects for use in the American economy.

Kenneth Sherman, a fishery biologist and Director of the Northeast Fisheries Center's Narragansett Laboratory, for designing and directing a research effort to analyse the consequences of the environmental contamination resulting from the oil spill from the Argo Merchant in December 1976.

Carroll I. Thurlow, Deputy Chief of the Oceanographic Division of the National Ocean Survey, for his "exceptional ability in the planning, organization, and implementation of the National Ocean Survey tidal datum survey program" which was necessary for the implementation of the management and protection of the nation's wetlands and coastal zone and for the determination of coastal and marine boundaries.

Philip Williams, Jr., Chief of the Meteorological Services Division of the National Weather Service's Western Region Headquarters in Salt Lake City, Utah, for his numerous contributions to the improvement of weather services.

Silver medals were awarded to the NOAA ships Heck and Rude for rescuing the crew and scientists from the burning vessel, M/V Midnight Sun, and saving the vessel from total loss. The crews actions demonstrated superior performance of duties and exceptional courage in a maritime emergency beyond the call of duty. The incident occurred July 7, 1977 in the Gulf of Mexico, 27 nautical miles from Freeport, Tex.

NOAA ship Heck
Lt Cdr. Thomas W. Ruszala
Lt. (jg) Charles E. Gross
Mark Aldridge
Horace B. Harris
Charles J. Gentilcore
Dennis S. Brickhouse
Robert T. Linton
Arnold K. Pedersen
Joseph Wiggins
James P. Taylor

NOAA ship Rude
Lt. Cdr. Robert B. Smart
Ens. Samuel P. DeBow, Jr.
Lt. (jg) Kenneth G. Vadnais
William N. Brooks
Johnnie B. Davis
James S. Eamons
Kenneth M. Jones
Frank Krusz, Jr.
Anthony W. Styron
Elijah J. Willis

noaa/update

41 NOAA Awards Are Presented

Six NOAA employees and 33 NOAA units were honored at the NOAA 1978 Awards Luncheon at the Bolling Air Force Base Officers club in Washington, D.C.

A joint award for Public Service went to *Robert J.C. Burnash*, NWS River Forecast Center, Sacramento, Calif., and *Arthur F. Gustafson*, WSFO, San Francisco, Calif., for their performance during the 1975–77 California drought.

Burnash and Gustafson recognized the potential crisis situation early in the drought period and took appropriate steps to inform local, State and Federal officials and to generate positive public response in easing the hardships caused by the drought.

Dr. John A. Brown, Jr., National Meteorological Center, NWS, who heads the Development Division, was the recipient of NOAA's Engineering and Applications Development Award. The award is "for unusually significant contributions to the operating or research programs of NOAA through achievements in engineering, applied technology, or systems or equipment development."

Dr. Brown, who built the Development Division into a research organization of international recognition and leadership in its field, has led his staff in improving the central guidance issued to field forecasters. Weather analyses and forecasts issued around the clock by the NMC are the basis for the entire national weather forecast service and are also used by many foreign weather services.

Winfred H. Meibohm, Acting Executive Director, NMFS, received NOAA's Program Administration and Management Award for his major role in the development of policy supporting the Fishery Conservation and Management Act of 1976, and for his performance as Acting Chief of the Marine Mammal and Endangered Species Division where he laid the foundation for the current favorable progress toward the resolution of the tuna-porpoise problem. He is also commended for his performance of regular responsibilities.

For unusually significant contributions to scientific research and development and outstanding contributions to scientific literature, *Dr. Carleton J. Howard* of the Aeronomy Laboratory, Environmental Research Laboratories, was awarded NOAA's Scientific Research and Achievement Award.

Dr. Howard's research in neutral kinetics led him to uncover a large error which existed in the accepted value for a reaction that enters in a basic way into the production and destruction of ozone in the troposphere and stratosphere. The new measurement has caused a substantial revision in estimates of the impact of man-made chemicals on the ozone layer, specifically from fertilizer, SST's and halocarbons. This research was selected by *Science News* as one of the major new developments in chemistry in 1977.

NOAA's Equal Employment Opportunity Award went to *Howard A. Friedman*, Tropical Weather Analyst at the National Hurricane Center in Miami, Fla. As chairperson for the Center's EEO Committee for the past four years, Friedman advanced EEO training, awareness, and concepts in the Center and in the community. Among many contributions, he developed and monitored training programs for minorities, women, and low grade employees, as well as for foreign visitors who train in Miami. Friedman's EEO work also has been recognized by organizations other than NOAA.

Unit Citations

A Unit Citation recognized groups of employees who, through their individual and collective efforts, have made substantive contributions to the programs or objectives for which NOAA was established. These groups are:

- *Hydrographic Field Party #1*
- *WSFO Chicago*
- *Flight Edit Program Members, FY 1977*
- *WSFO Cleveland*
- *Budget and Finance Office, PMC*
- *NOAA ship Townsend Cromwell*
- *Horizontal Control Party G-19*
- *WSFO Portland*
- *WSFO Boston*
- *Quality Control Branch, Marine Surveys and Maps*
- *WSO Athens*
- *WSO Columbia*
- *NOAA ship Surveyor*
- *Operation Fish Flow, 1977*
- *Staff of the New York (JFK), WSO*
- *Mesometeorological Program Group of APCL*
- *WSFO Raleigh*
- *WSO Beckley*
- *Foreign Fishery Observer Task, NWAFC*
- *NOAA ship Researcher*
- *Southeast Inspection Office*
- *WSFO New York*
- *Law Enforcement Branch, Fisheries Management Division, Northwest Region*
- *National Seafood Quality and Inspection Laboratory*
- *Special Projects Branch, Satellite and Space Support Division*
- *Staff, WSO Bristol*
- *WSFO, Fort Worth*
- *Ohio River Forecast Center, Cincinnati*
- *Climate Diagnostics Project*
- *Disaster Preparedness Staff*
- *WSO Huntington*
- *Central Flow Control Facility, ATCSCC*
- *WSFO Charleston*

Special Awards

Dr. Wilmot Hess, Director of the Environmental Research Laboratories in Boulder, and Davis S. Johnson, Director of the National Environmental Satellite Service in Suitland, Md., were awarded Special Achievement Awards for their significant contributions to NOAA. The $1000 awards were presented at the NOAA Awards Ceremonies, October 6.

Hess and Johnson were honored specifically for their work during the transition of NOAA Administrators.

Southern School Gets NOAA Help

A concern about the small number of minorities and women in the oceanic and atmospheric sciences has led NOAA to help expand a meteorology program at Jackson State University in Jackson, Miss.

NOAA provided a meteorologist to organize a Bachelor of Science degree program in meteorology at the predominently black institution.

Dr. Keith W. Johnson, of NOAA's National Weather Service, was named Visiting Professor of Meteorology in Residence for a two-year period. Under Title VII of the Civil Rights Act, the major portion of his salary will come from NOAA.

Dr. Keith W. Johnson

Jackson State began a limited meteorology program in 1976, the first of its kind in the country.

Film On Global Weather Experiment Available

The Global Weather Experiment—A Whole Earth View is the title of a new, 14-minute film from NOAA.

The 16-millimeter color film uses a unique back-lighted form of animation to depict some of the problems of forecasting the weather as well as to illustrate the global scope of the experiment and planning for it.

The film is cleared for television, and arrangements may be made for long-term loan or purchase from a commercial laboratory.

Copies of *The Global Weather Experiment—A Whole Earth View* may be borrowed without charge, postage-paid, from NOAA Motion Picture Services, 12231 Wilkins Ave., Rockville, Md. 20852.

noaa/update

TV Weather Show Goes On The Air

"A.M. Weather," a 15-minute public television weather program went on the air October 30, with three NOAA meteorologists, H. Michael Mogil and Richard Warren of the National Weather Service, and Dale Bryan of the National Environmental Satellite Service.

The program, produced by the Maryland Center for Public Broadcasting, is designed primarily for private pilots and other aviators but also has special appeal to practically anyone needing comprehensive weather information for planning purposes. It is scheduled for viewing every weekday during the breakfast hours. There are two "live" broadcasts—at 6:45 a.m., EST, emphasizing Eastern weather, and at 8:45 a.m., EST, focusing on Western conditions—and two taped repeat broadcasts at 7:45 and 9:45 a.m., EST. Local stations carrying the shows select their own schedules.

Each show includes an overall look at the weather nation-wide, a description of factors expected to affect the weather for the next two days, and detailed forecasts for various regions. Along with weather maps, there are satellite photos and other visual aids to promote easy understanding.

Although "A.M. Weather" is tailored after "Aviation Weather," a Friday evening program that ran on many PBS stations from 1972 to 1976, this is the first time professional NWS and NESS meteorologists have been on the air giving live forecasts.

NOAA Scientists Study Flash Floods

Flash floods, which caused more than $1.5 billion in property and crop damage and in excess of 100 deaths in the United States in 1977, seem to strike most often at night during the summer, according to a recent study of significant flash floods made by NOAA scientists.

The NOAA study, conducted by Robert A. Maddox and Dr. Charles F. Chappell of the Environmental Research Laboratories, was undertaken to identify specific, large-scale weather patterns that are associated with intense rainfall, and to isolate common features that trigger and focus these events.

After examining data on 20 significant flash floods in the United States between 1972 and 1977, the NOAA scientists unearthed some striking similarities. For example, the heavy rains responsible for 15 of the floods began between 6 p.m. and 6 a.m.

"This nocturnal characteristic complicates the forecast and warning problem, since public response to warnings is slowest during the late evening and early morning hours," Maddox and Chappell, both meteorologists with NOAA's Atmospheric Physics and Chemistry Laboratory in Boulder, Colo., reported. "Additional research is needed to identify the mechanisms responsible for the nocturnal focusing and intensifications of these storms."

Another similarity which surfaced from the study: the largest number of flash floods, seven, struck during the month of July. These included the Big Thompson Canyon, Colo., tragedy of 1976, and the Johnstown, Pa., disaster in 1977. Four of the 21 floods, occurred in September, three each in June and August, two in May, and one each in April and October.

Detailed meteorological analyses of the floods made by the two NOAA scientists let them piece together certain geographical, meteorological, and time-of-day characteristics which could combine to produce a serious flash flood in the United States.

The hypothetical flood likely would be caused by thunderstorm rains in a region of unusually high atmospheric moisture content. Changes in wind velocity from the top to the bottom of the storm would be small. And other convective storms or new thunderstorm clouds would develop so that accompanying rains would repeatedly affect the same general area.

NOAA's Rick Roberts Pedals His Way Across The Country

Rick Roberts

Taking 84 days to go from Williamsburg, Va., to Astoria, Oreg., may sound like 19th century travel. But NOAA's Rick Roberts went by bicycle. All 4500 miles cross-country.

Participating in the bicentennial Bike-a-thon last spring, Roberts left Williamsburg May 22 in a group of 10, christened "Mangies" by a gas station operator in Virginia. They followed the TransAmerica Trail established during 1976, going west to Pueblo, Colo., north thorugh Yellowstone and Missoula, Mont., arriving in Astoria on August 13.

"We got a feeling of what the pioneers must have gone through on their trips West," said Roberts, recalling 105°F temperatures through the flat lands of Kansas and eastern Colorado and the awesome sights that greeted them when they crossed mountain passes, such as the Tagwotee Pass that leads to the Grand Tetons.

Averaging 65 miles a day, with a rest day every eight days, the group encountered unending hospitality in the homes and towns along the trail. They especially appreciated the "Cookie Ladies" who advertise their free refreshments by flying bike flags in the yards. "They can be life-savers, sometimes," said Roberts.

SUBSCRIPTION ORDER FORM

ENTER MY SUBSCRIPTION TO:

@ $ Domestic; @ $ Foreign.

NAME—FIRST, LAST

COMPANY NAME OR ADDITIONAL ADDRESS LINE

STREET ADDRESS

CITY | STATE | ZIP CODE

PLEASE PRINT OR TYPE (or) COUNTRY

☐ Remittance Enclosed (Make checks payable to Superintendent of Documents)

☐ Charge to my Deposit Account No. .....

MAIL ORDER FORM TO:
Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

United States
Government Printing Office
Division of Public Documents
Washington, D.C. 20402

Official Business

AN EQUAL OPPORTUNITY EMPLOYER

Postage and Fees Paid
U.S. Department of Commerce
Com-210

Controlled Circulation Rate

NOAA SERIA300SJISSDUE003R 1
SERIALS PROCESSING
UNIV MICROFILMS INTL
300 N ZEEB RD
ANN ARBOR MI 48106

Story on page 30

★ U.S. GOVERNMENT PRINTING OFFICE: 1979-281-036-1